ENVIRONMENTAL ACTION PROJECT PLANS

KENNECOTT CORPORATION
SALT LAKE COUNTY, UTAH

June, 1991

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SUMMARY

KENNECOTT ENVIRONMENTAL ACTION WORKPLANS

Kennecott Corporation, through its wholly owned subsidiary, Kennecott Utah Copper, produces copper and other metals from the Bingham Canyon Mine and associated processing facilities in the western portion of Salt Lake County. The facilities cover an area of approximately 50 square miles, embracing territory that has been mined by dozens of operators for more than 125 years. The residue of many of these operations is still evident, although only a few companies connected with these operations still exist. In general, the residues are located in areas remote from population centers, and contain materials with metals of relatively low concentration, mobility, and toxicity.

As part of Kennecott's continuing environmental program, a comprehensive review of Kennecott Utah Copper operations has been conducted. The results of this review were reported in an Environmental Response document, which was provided to the State of Utah and the EPA on April 11, 1991. That review identified a total of 13 areas within the Kennecott Utah Copper operation that had known or suspected environmental problems, and proposed responses. These sites are summarized in Table I.

Following the presentation of that document, Kennecott developed workplans for the majority of the sites as indicated by the shaded items in Table I. This document presents those workplans. The workplans for the remaining sites will be submitted in October 1991.

Table I - Environmental Response Actions Identified

	LOCATION	NATURE OF PROBLEM	PROPOSED RESPONSE	CURRENT STATUS
1	Bingham Creek Tailings	Soil with elevated lead and arsenic concentrations	Remove to repository on Kennecott property	CERCLIS site; Removal action underway in residential area; workplan to be prepared for remaining area
2	Bingham Channel Groundwater Plume	Acid and metal-bearing groundwater plume	Source control and natural remediation	CERCLIS site; Source control workplan prepared (Eastside Groundwater and Large Bingham Reservoir), investigation workplan prepared
3	Butterfield Waste Rock	Metal-bearing rock waste eroding into stream	Remove to Kennecott waste dump area	CERCLIS site; removal workplan prepared
4	State Motorcycle Park Tailings	Exposed metal-bearing tailings; groundwater impact	Investigate nature of material; cover and revegetate	CERCLIS site; investigation workplan prepared
5	Lark Waste Rock	Metal-bearing waste rock	Investigate material; remove to waste dump toe	CERCLIS site; investigation workplan prepared
6	Magna Tailings Pond	Tailings dust, suspected groundwater contamination	Dust suppression	CERCLIS site; dust controlled, groundwater investigated
7	Kennecott Power Plant	No known impact	Upgrade ash slurry system	CERCLIS site; no action suggested
8	Smelter Slag Pile and Lagoon	Exposed slag, flue dust, and sediments; seepage to groundwater	Remove flue dust and sediments, drain lagoon, revegetate	CERCLIS site; workplan to be prepared
9	South Jordan Evaporation Ponds	Exposed metal-bearing sludge, possible seepage impact	Recontour berms, selective covering, reclamation	CERCLIS site; investigation workplan prepared

(table continued)

	LOCATION	NATURE OF PROBLEM	PROPOSED RESPONSE	CURRENT STATUS
10	Kessler Canyon Drainage	Metal-bearing soil, groundwater degradation	Control ground and surface water at smelter, soil treatment	Workplan to be prepared
11	Magna Soils	Possible elevation of metals content in soils	Comprehensive survey	Investigation workplan prepared
12	Diving Board Area Tailings	Potential impact on air and surface water quality	Remove tailings, construct basin, control water	Removal workplan prepared
13	Wastewater Treatment Plant Sludge	Sludge, groundwater degradation	Remove and treat sludge, dispose in tailings pond	Workplan to be prepared

Note: Shading indicates projects included in the current workplans

The projects that are included in this package fall into three categories of activity: source control actions, removal actions, and site characterizations. The work proposed in this package can be accomplished with available resources within the timeframes set out in the workplan schedules.

SOURCE CONTROL ACTIONS

EASTSIDE GROUNDWATER

Surface and groundwater infiltration into the alluvial fan deposits which extend eastward from the mouth of Bingham Canyon near Copperton has created a plume of acidic, metal-bearing water which covers approximately 1,500 acres downstream from Copperton along Bingham Creek. The current strategy for control and remediation of the plume includes elimination of sources of acid water to the plume. Many of the sources of acid seepage have already been eliminated by the installation and upgrading of the leachate collection system since 1965. However there is evidence that some acid leachate still escapes from the system at several locations.

Objective

The objective of this program is to determine the effectiveness of the eastside leachate collection system, and to construct facilities to complete the source control of acid leachate.

Program

The proposed activities are as follows:

- Investigation. To determine the effectiveness of the current source control three areas will be investigated:
  - Bingham Creek channel
  - Eastside leach collection system
  - Deep path seepage through rock beneath dumps.

  All wells in the area will be monitored. A report on the investigation will be prepared.

- Construction. Three sets of actions will be undertaken based on the results of the investigation to complete source control of acid leachate:
  - Construct seepage cutoff barrier across Bingham Creek Channel
  - Install leachate collection systems on gulches along eastside dumps that currently permit leachate escape
  - Extend the stormwater collection canal to the south to collect all runoff and seepage from disturbed areas.

  As-built details of construction will be provided.

LARGE BINGHAM RESERVOIR

The Large Bingham Reservoir is located to the east of Copperton. It was constructed in 1965, and has since that time stored acid and metal-bearing water as part of the stormwater management system of the Kennecott Utah Copper's Bingham Operation. Leakage from the facility has resulted in some contamination of the alluvial aquifer beneath. To prevent this leakage, Kennecott has undertaken an extensive program to line 460 acre feet with 12 inches of clay and with HDPE.

Objective

The objective of the proposed environmental response program is to prevent acid or metal-bearing water seeping from the Large Bingham Reservoir to the groundwater system.

Program

The implementation of the proposed action comprises the following:

- Site preparation, involving dewatering of the reservoir; removal or in-situ stabilization of sludge and copper tailings from within the reservoir basin; and preparation of the surface for the liners.

- Reservoir Lining, involving placement of a 12" clay liner; placement of a 60 mil (0.060") HDPE liner.

- Miscellaneous Construction, involving construction of a valved reservoir inlet structure; additional temporary concrete structures for diversion of water and overflow.

- Pump Station Refurbishing, involving foundation stabilization; structural strengthening; upgrading pumps, piping, and valves; and instrumentation.

As-built details of construction will be provided.

REMOVAL ACTIONS

BUTTERFIELD WASTE ROCK

The Butterfield Waste Rock pile is located in a steep-sided reach of Butterfield Canyon about three miles west of the town of Lark. The waste rock was produced during construction of the Butterfield Drainage Tunnel and mining operations by the Combined Metals Reduction Company in about 1912; the pile contains about 1.4 million tons and covers about 15 acres. There are an additional 75,000 tons of waste rock and tailings downstream from the dump. The waste contains arsenic, barium, cadmium, copper, lead, and zinc; however the material is not significantly leachable nor acid producing. The material is being actively eroded by the stream which flows over it.

Objective

The objective of the proposed environmental response program is to prevent further erosion of the waste rock materials into the stream channel.

Program

Kennecott plans to relocate the mine waste to a disposal area in Castro Gulch. This action requires the following:

- Prepare the disposal area in Castro Gulch: build retaining embankment; build haul road to repository site.

- Prepare Butterfield area: Divert stream and Butterfield Tunnel with cofferdam above and sediment dam below; relocate gas pipe out of streambed.

- Remove waste rock: Excavate and transport waste rock to repository; revegetate.

- Reclaim Butterfield site: Reclaim, revegetate and stabilize excavation site and haul roads.

As-built construction details will be provided.

DIVING BOARD

The Diving Board Area is located north of the Magna Concentrator. This 21-acre impoundment has been used for many years to impound tailings overflow during periods of scheduled and emergency shut down, and to control and direct surface water in this area. The Diving Board Area currently contains approximately 450,000 cubic yards of tailing and other materials. Dust from the Diving Board area has the potential to affect air quality.

Objective

The objectives of the Diving Board removal action are to eliminate the possibility of air or surface water impact and to facilitate tailings and surface water management.

Program

The actions to be undertaken to achieve the objectives are:

- characterization of the tailings to ensure that they can be disposed of in the Magna Pond;

- site preparation activities, comprising pipe relocations and structure removal;

- tailings removal, using excavation and slurry transport to the Magna Tailings pond;

- construction of concrete-lined impoundment.

As-built details of construction will be provided.

SITE CHARACTERIZATIONS

BINGHAM CREEK GROUNDWATER PLUME

Surface and groundwater infiltration into the alluvial fan deposits which extend eastward from the mouth of Bingham Canyon has created a plume of acidic, metal-bearing water which covers about 1,500 acres downstream from Copperton along Bingham Creek. The groundwater plume contains an estimated 110,000 acre feet of contaminated water. Monitoring of the plume shows little migration of the low-pH, high metals part of the plume during the past five years, as a result of source controls and neutralization reactions between the plume and the host alluvium.

Objective

The objective of this site characterization is to develop a more complete understanding of the behavior of the plume, and to install a system of wells to more closely monitor the effectiveness of source control and neutralization in eliminating the plume.

Program

The proposed activities are as follows:

- Install monitoring wells in and around the plume to more adequately identify the geology, soil chemistry, groundwater quality, and geohydrology parameters.

- Conduct a surface geophysical exploration and deep well installation to define the geologic setting of the plume, to better understand of the past and future behavior of the plume.

- Conduct a large (room) scale chemical testing program to demonstrate the chemical processes which are occurring as the plume contacts saturated alluvium.

A comprehensive site characterization report will be prepared integrating all available information and providing analysis and conclusions about the plume behavior based on that information.

SOUTH JORDAN EVAPORATION PONDS

The South Jordan Evaporation Ponds, located 7 miles east of the Bingham Mine, were used between 1936 and 1965 to store and evaporate Bingham Canyon watershed waters and waste dump leach process waters. Following construction of the Bingham reservoir in 1965, the ponds have been used on an emergency basis. Presently the site is dry, and contains about 4,600,000 tons of sludge covering about 375 acres. The sludges contain detectable arsenic, copper, lead, and zinc; but leach testing indicates limited groundwater contamination potential. Environmental actions considered by Kennecott consist of in-place remediation by covering some or all of the sludge, and revegetating.

Objective

The objective of the proposed site characterization program is to characterize the sludge materials.

Program

The site characterization will include the following:

- Characterization of the volume, depth, physical and chemical characteristics of the sludge materials in the various ponds.

- Evaluation of the extent to which the pond materials are contributing metals to groundwater.

Samples will be obtained from backhoe trenches and auger holes through the sludges and underlying subsoils. Two groundwater monitoring wells will be drilled and an air monitoring station installed.

A site characterization report describing the results of all studies will be prepared. This report will be used for subsequent evaluation of the most effective environmental action for these materials.

STATE MOTORCYCLE PARK TAILINGS

The State Motorcycle Park tailings, located just east of the town of Lark, were generated from copper ores from the Mascotte Mine and were deposited between 1909 and 1918 by the Ohio Copper Company. Kennecott leased the site to the Utah State Division of Parks and Recreation for use as a motorcycle park from 1977 until 1989. There are approximately 5,000,000 tons of tailings distributed over about 350 acres. The tailings contain metals, and are subject to acid generation. Environmental actions considered by Kennecott consist of covering some or all of the tailings, and revegetation.

Objective

The objective of the site characterization is to investigate potential acid generation, airborne dispersion, and groundwater contamination as a result of the tailings.

Program

The investigation program includes chemical, physical, and volumetric characterization of the tailings. Specific activities are:

- excavation of backhoe trenches and drilling auger holes into and through the tailings;
- installation of groundwater monitoring wells; and
- installation of an air monitoring station.

A site characterization report integrating information gained from this and previous investigations will be prepared. This document will be used for subsequent evaluation of the most effective environmental action for these materials.

LARK WASTE ROCK

The Lark Waste Rock Site consists of approximately 1,300,000 cubic yards of waste rock located in a total of six abandoned mine waste dumps which occupy an area of 40 acres directly east and north of the town of Lark. The waste rock originated from underground mining operations conducted in the late 1800s and early 1900s. Previous testing of the dumps has shown that the waste material contains measurable concentrations of copper, iron, lead, and zinc. Much of the material is acid generating and leaches low to moderate levels of selected metal species. Environmental actions considered by Kennecott consist of either in-place remediation or removal of the waste rock.

Objective

The objective of the site characterization is to investigate acid generation potential of the waste rock and whether waste rock has impacted groundwater quality.

Program

The investigation program includes chemical, physical, and volumetric characterization of the tailings. Specific activities are:

- excavating backhoe trenches and drilling auger holes into and through the tailings;
- installation of groundwater monitoring wells; and
- installation of an air monitoring station.

A site characterization report integrating information gained from this and all previous investigations will be prepared. This report will be used for subsequent evaluation of the most effective environmental action for these materials.

MAGNA SOILS

The town of Magna is located in an industrialized area of western Salt Lake County. The presence of these industrial operations has raised concerns that local soils may be contaminated with metals. Potential sources of these metals include ore concentrates, blowing tailings dust, smelter particulate emissions, phosphate plant emissions, and auto exhaust. Available data indicates metals concentrations that are not considered to pose a significant threat to human health or the environment. However data is limited, and it is not possible to make definite conclusions about the soil metals levels.

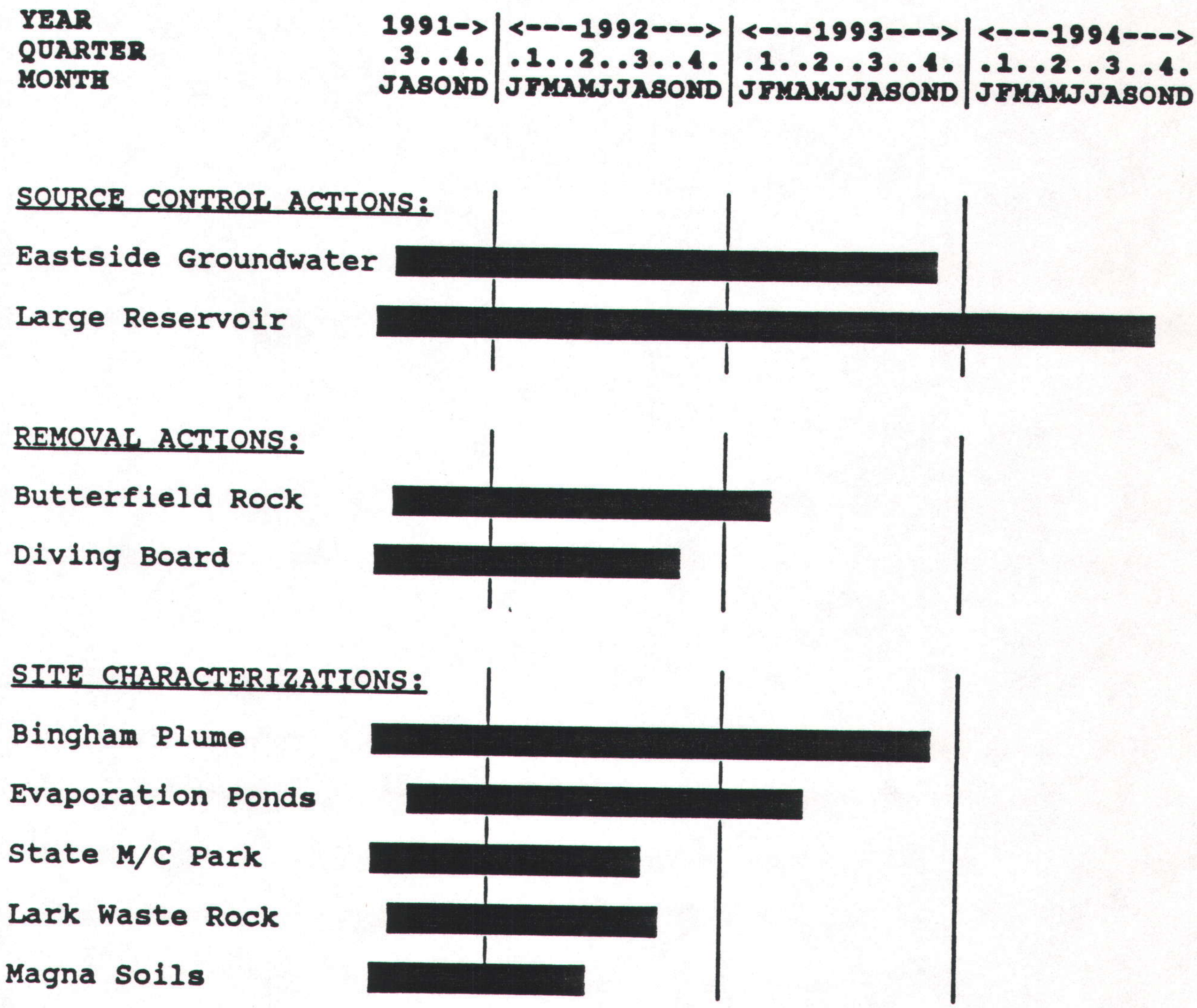
Objective

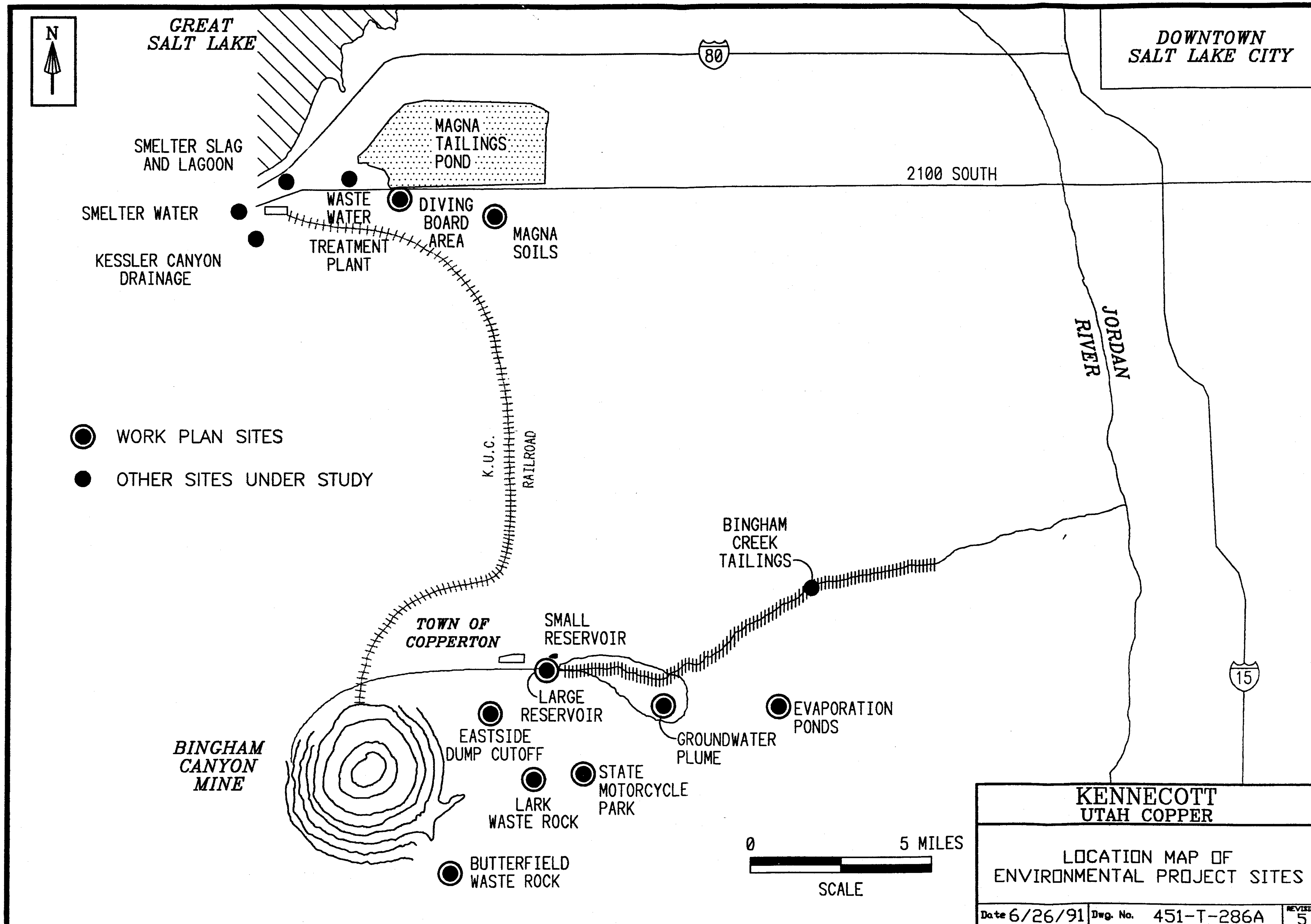
The objective of this program is to determine with greater certainty the extent of metals present in Magna near surface soils and to evaluate the cause of any high metal concentrations found.

Program

The scope of this investigation is to sample and analyze soils samples taken at a range of depths at approximately 150 locations throughout the town of Magna. These results will be added to prior results from the town. If warranted by the findings, further investigation may be performed. The study will result in the preparation of a report on the soil metal concentrations in Magna.

SCHEDULE - OVERALL PROGRAM





KENNECOTT UTAH COPPER		
LOCATION MAP OF ENVIRONMENTAL PROJECT SITES		
Date 6/26/91	Dwg. No. 451-T-286A	REVISION 5

PROJECT PLANS
FOR
EASTSIDE GROUNDWATER SOURCE CONTROL

SALT LAKE COUNTY, UTAH

Report 1212T/910604
June 4, 1991
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1.0 OVERALL WORKPLAN

1.1 INTRODUCTION/BACKGROUND STATEMENT

The primary drainage from the Bingham Mine is Bingham Creek, which drains eastward from the Oquirrh Mountains approximately 10 miles to the Jordan River. The Bingham Pit has intercepted what was originally the upper reaches of the creek and, since 1965, the Bingham Reservoir has impounded flow as the creek leaves the mountains. The dump leach operations surrounding the Bingham Pit lie above the Bingham Reservoir in the upper Bingham Creek drainage basin. Leachate from this operation is collected in a leach collection system that routes leachate to the precipitation plant, where copper is removed and the water recycled to the dumps. Most of the runoff from the waste dumps and associated disturbed areas is collected in a peripheral stormwater system and directed to the Bingham Reservoirs, for recycling and/or treatment.

The water table along the dump front and beneath the Bingham Creek Channel ranges greatly, dependent on several factors including distance from the Oquirrh Mountain front. However, the depth to water is generally within 200 feet of the surface. There are two lithologic units of significance in the Bingham Creek area: Tertiary volcanic bedrock, and overlying unconsolidated to semi-consolidated alluvial fan sediments of late Tertiary and Quaternary age. Both dip eastward at low to moderate angles into the Jordan Valley. Alluvial fan sediments thicken abruptly eastward from less than 50 feet to hundreds of feet at the margin of the Oquirrh foothills.

Over time, surface and groundwater infiltration east and downgradient of the Oquirrh Mountains has created a plume of acidic, metal-bearing water that covers approximately 1,500 acres downstream from Copperton along Bingham Creek Channel (shown in Figure 1 below). The plume is contained entirely within the alluvial fan sediments. Potential sources of groundwater contamination may be the result of:

- natural leaching and erosion of mineralized outcroppings, waste rock and tailings; and/or
- leachate solution bypassing the current leachate cutoff system.

The principal active remedial activity that is being undertaken with respect to the acid plume is the elimination of contaminant sources. To date a number of source elimination programs have been conducted:

1. Collection of the leachate from the dumps and stripping metals at the precipitation plant;

2. Collection of surface flow down Bingham Creek Channel in Bingham Reservoir, and recycling to the waste dumps;

3. Collection of acid groundwater flow in the Bingham Creek alluvium above the reservoir, and pumping to the precipitation plant or Bingham Reservoir as appropriate;

4. Diversion of snow melt and stormwater from Bingham Pit through the pipeline system to Copperton Concentrator to be used as process water;

5. Diversion of in-pit drainage to treatment facilities at the Copperton Concentrator;

6. Lining of the small Bingham Reservoir for collection of leachate solution overflow with a pumping and pipeline system for treatment and recirculation of excess water;

7. Elimination of the use of the South Jordan Evaporation Ponds;

8. Reduction in the volume of water flowing in the upper reaches of Bingham Creek; and

9. Lowering the operating level of the large Bingham Reservoir.

The program described in this workplan is intended to identify and control any remaining sources of acid and metal-bearing water which may cause contamination of groundwater in the Jordan Valley.

1.2 OBJECTIVES

The objective of the proposed Eastside Groundwater Contamination Source Control Program is to eliminate escape of acid and metal-bearing water from the leach collection system at the Bingham Operation. The program is intended to investigate all drainages east of the leaching operations from Bingham Creek to Butterfield Canyon and to engineer contaminant water management strategies which prevent contaminated water from entering the groundwater flow system outside of the leachate collection system area.

1.3 SCOPE

The proposed program comprises the investigation of the current leachate system, to evaluate the location and extent of leachate escape from the system. Upon completion of this investigation leachate cutoff systems will be installed as required.

1.3.1 Investigation

Further investigations will be conducted and monitoring points installed to determine the effectiveness of the existing and proposed cutoff system. Investigations are intended to identify any present-day sources of contaminated water entering the groundwater system, and to provide information needed to design source control measures.

Specific activities to be conducted are as follows:

- Drill 28 pairs of exploration holes along the area east of the Eastside dumps (approximate locations given on Figure 1);
- Drill three oriented core holes at the toe of the Eastside Dumps, one each in Bluewater I, Midas, and Keystone Gulches.
- Drill 12 exploration holes at 10 locations in the Bingham Creek channel area (approximate locations given on Figure 2);
- Sample soil, water, rock during drilling and permeability testing;
- Run geophysical borehole logs to evaluate geology, hydrology, and water chemistry;
- Test basement permeability using packer, slug, and pumping test methods;
- Complete test holes as monitoring wells in either alluvium, alluvium/bedrock interface, or bedrock based on the information collected at the test hole location;[1]

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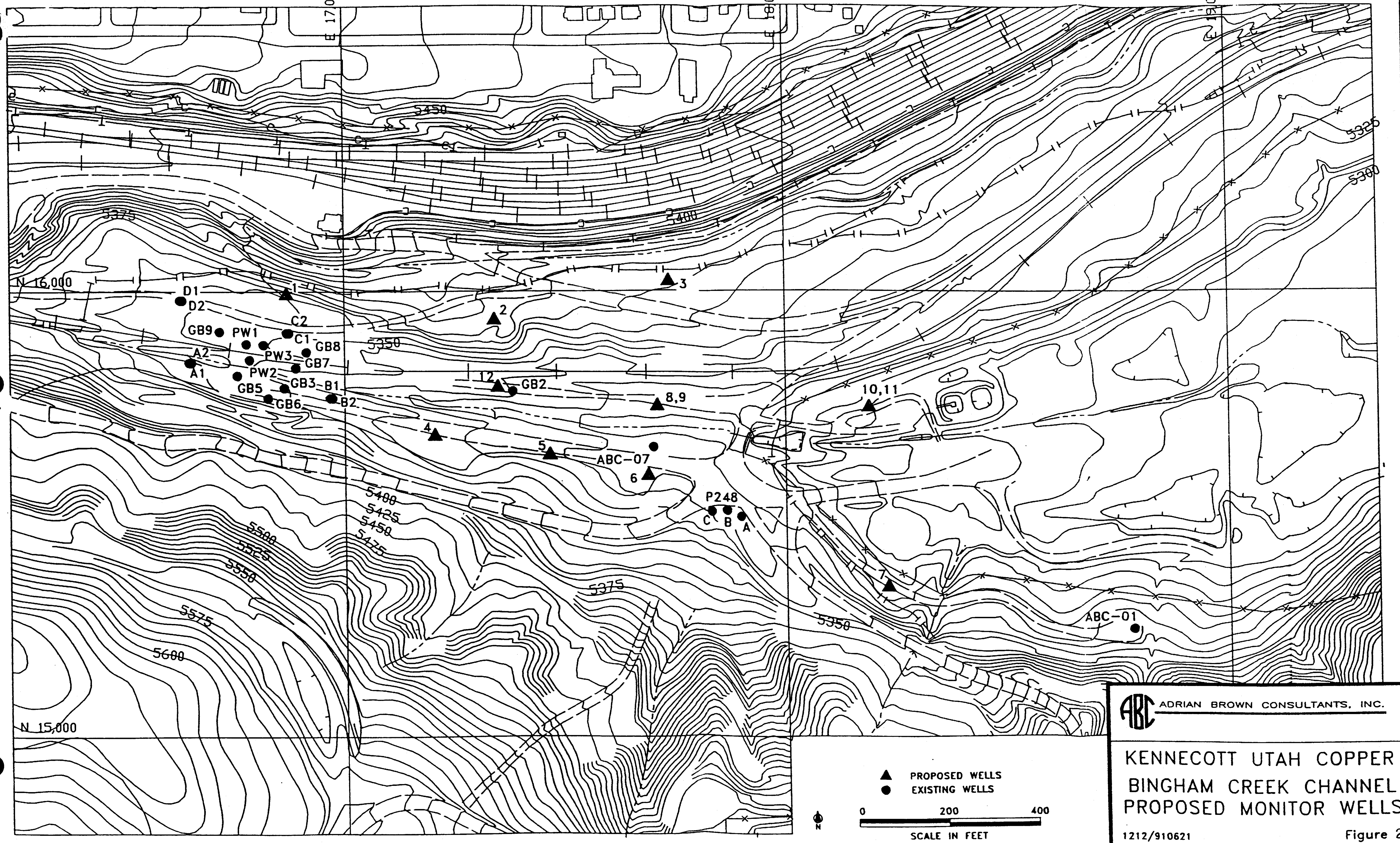
[1] Note that one or more monitoring wells may be established at the same location where more than one completed interval is necessary (e.g., alluvium and bedrock monitoring).



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KENNECOTT UTAH COPPER
BINGHAM CREEK CHANNEL
PROPOSED MONITOR WELLS

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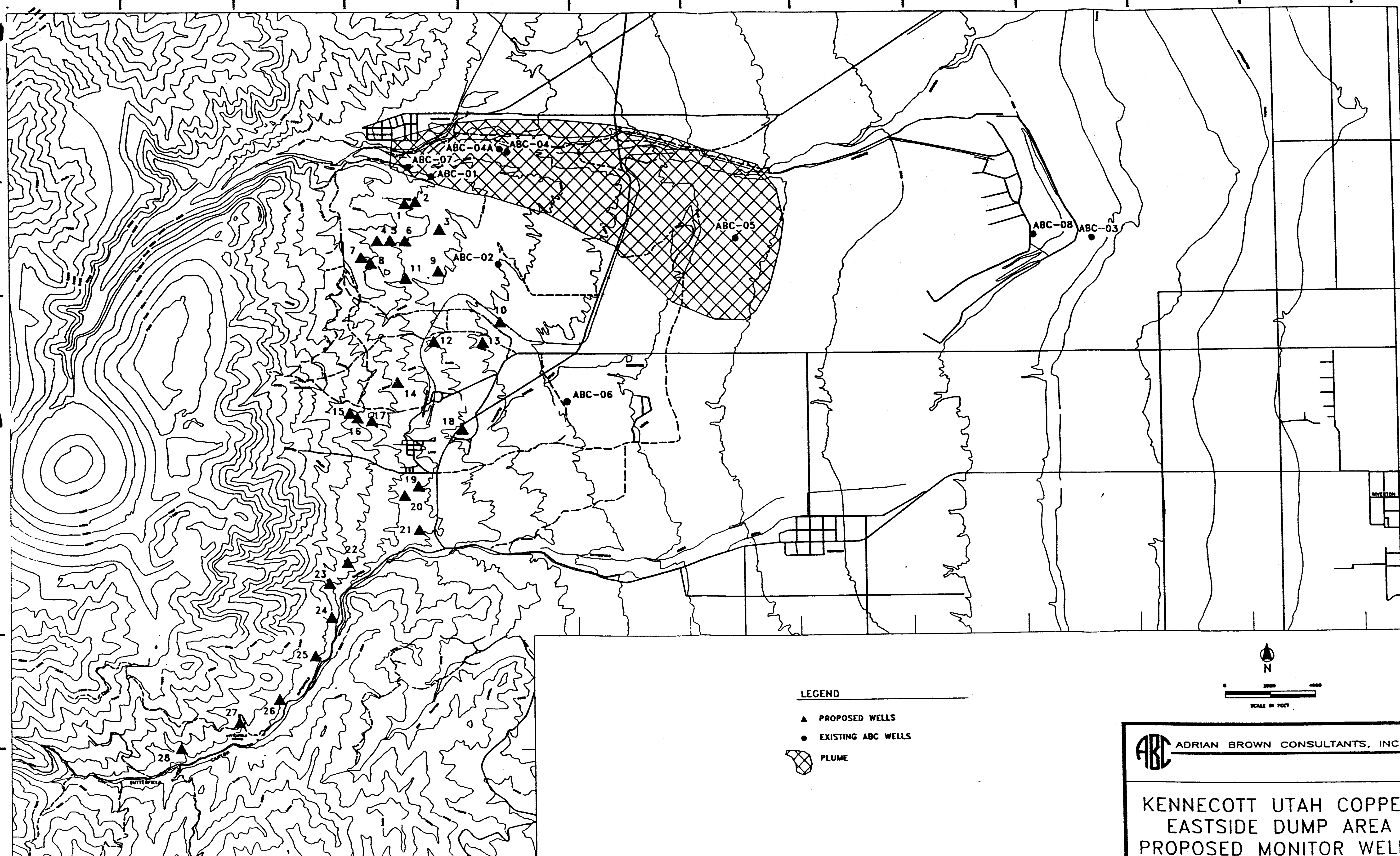
Figure 2



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KENNECOTT UTAH COPPER
EASTSIDE DUMP AREA
PROPOSED MONITOR WELLS

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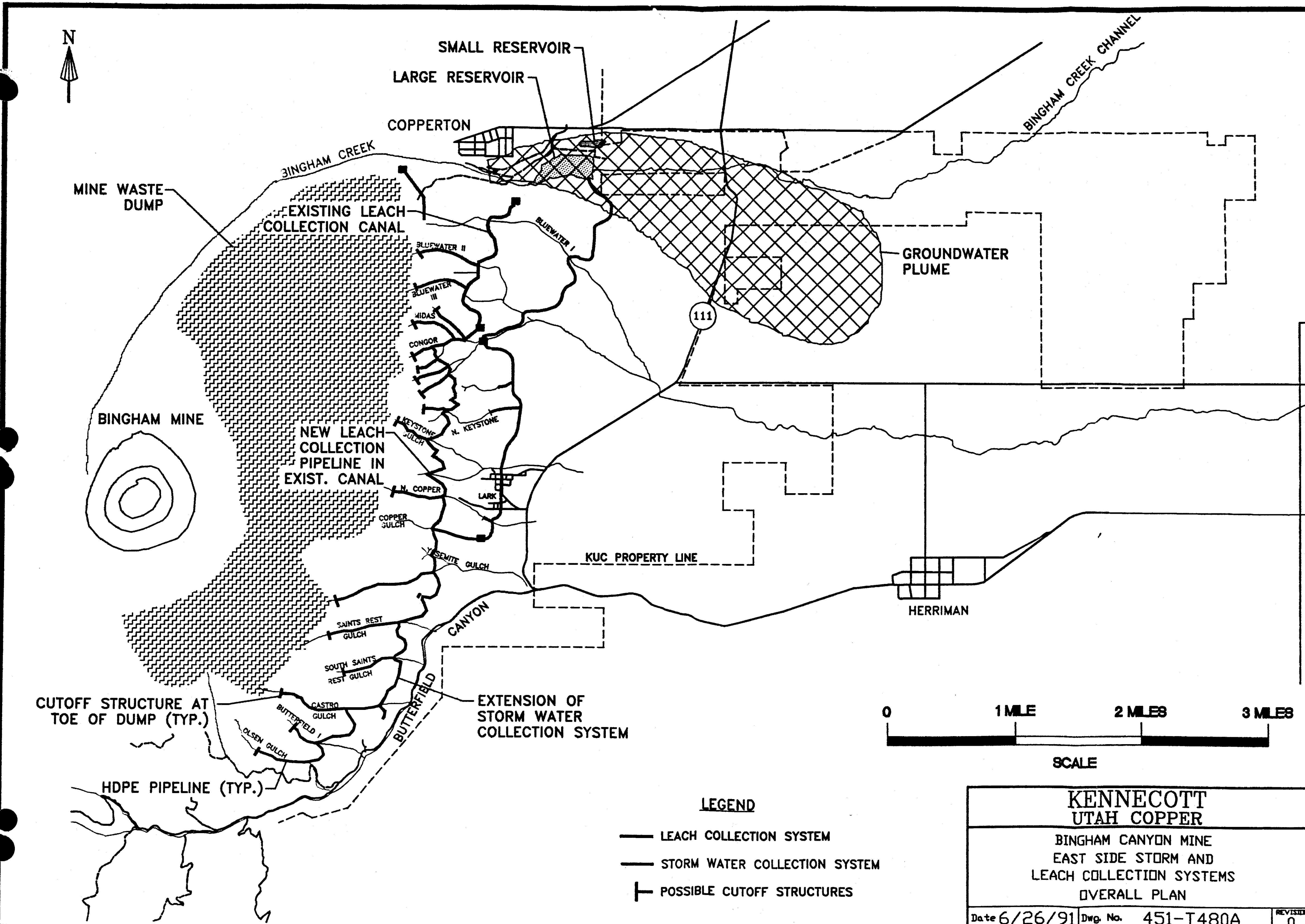
Figure 1



KENNECOTT
UTAH COPPER

BINGHAM CANYON MINE
EAST SIDE STORM AND
LEACH COLLECTION SYSTEMS
OVERALL PLAN

Date 6/26/91 | Dwg. No. 451-T480A | REVISION 0

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- Measure water levels;
- Sample completed wells;
- Integrate data collected with other subsurface information;
- Establish/continue monitoring program;
- Develop source control plan and design cutoff system.

These activities will produce the following results:

- Establish adequate information to determine contaminant sources;
- Establish adequate information to determine effectiveness of current source controls;
- Initiate design of additional source controls, as necessary.

1.3.2 Construction

Three construction activities are considered to be necessary to complete source control of acid leachate from the Bingham Operations. They are described below:

1. Completion of leach cut-off in Bingham Channel. In the event that further cutoff effort is shown to be needed, additions to the current cutoff system will be designed and implemented. Prior to performing the investigation is not known what this will involve, but it is anticipated that the following strategies might be taken:
   - Upgrading the existing well extraction and pumpback system.
   - Installation of either a constructed concrete wall or a slurry wall to cut off the flow, plus a pumpback system based on a collector sump behind the cutoff wall.

2. Improvement of the eastside leach collection system cutoff. The improvement of the eastside leachate cutoff system will require the following activities:

- Extension. The eastside leach collection system will be extended to all active leach dump areas. This will require the addition of three miles of main collection pipeline, five miles of spur pipelines, eleven cutoff structures in the canyons included in the system, and the installation of a power supply to provide power for the collection system.

- Upgrading. For the existing eastside cutoff dams which are found to be ineffective during the investigation phase of the project, well reclaim systems will be designed, installed, and the leachate pumped back into the leach collection system at those locations.

These two actions are expected to complete the cutoff of leachate from the leach and other portions of the Bingham Operations. It is noted that the investigation into the deep flow system through the bedrock discussed above is expected to confirm that this is not a significant pathway for acid migration. In the event that this pathway is found to be significant, a further investment proposal will be developed for remediation.

3. <u>Stormwater collection system extension.</u> The extension of the stormwater canal to the south will result in the complete collection of all runoff from the dump system, including any leachate which may have formed from meteoric water (these dumps are not deliberately leached). The activities that are included in this proposal are:

- Construction of pioneering roads to access the area.

- Construction of seven cutoff walls to contain the seepage from the Copper Queen Mine.

- Construction of 4½ miles of cutoff discharge pipelines.

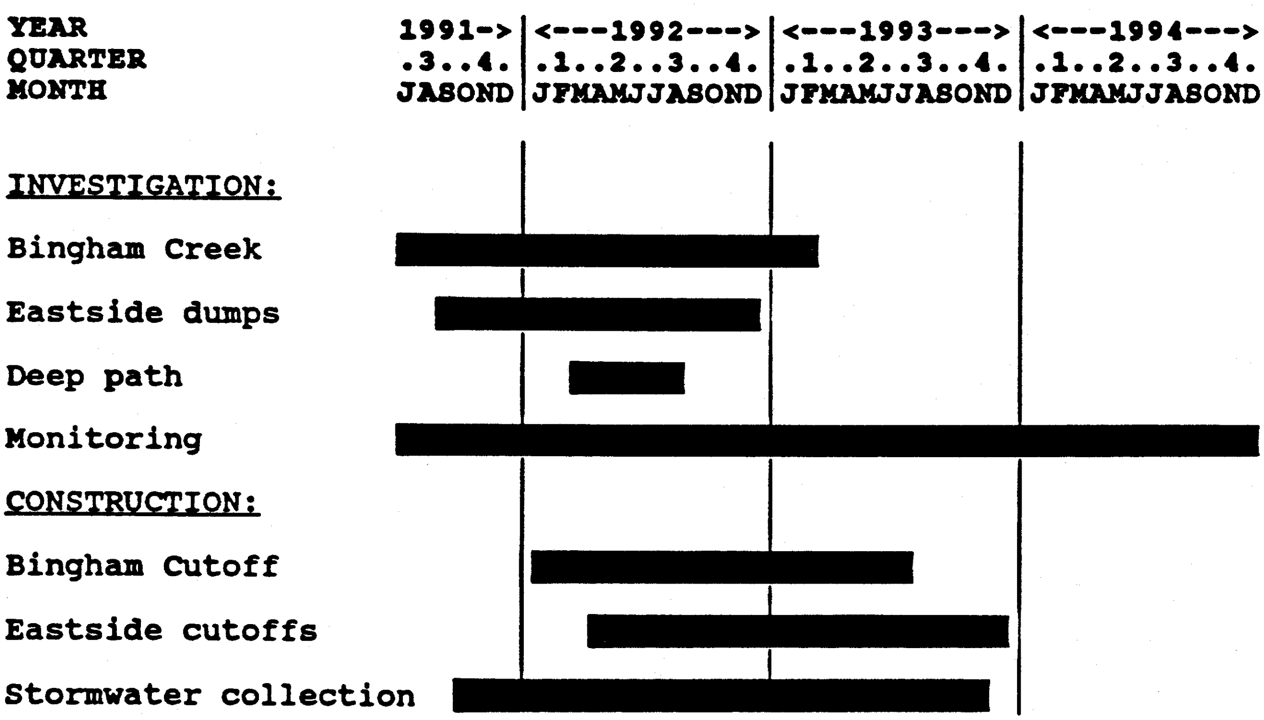
- Construction of 3½ miles of main collection pipeline from the Copper Queen mine area to Castro Gulch (the current end of the collection system).

- Construction of up to five well pumping systems to collect and dispose of any acid leachate that is identified in the investigation stage of the project.

These actions will collect stormwater from disturbed mine lands south of the town of Lark, and will cut off any acid seepage which is being generated in this area.

The need for, configuration of, and design of these construction projects will be evaluated once the investigation project has been completed.

1.4 WORK SCHEDULE



1.5 DELIVERABLES

The principal deliverable of the project will be the completion of the cutoff of leachate seepage from the Bingham Operation.

Written deliverables for the project will be as follows:

1. A report describing the overall sources and flow paths of contamination, the current effectiveness of controls on these contaminant sources, and the design of additional controls deemed necessary for complete containment.

2. A report describing the results of the 1991 field program, integrating the information gained with prior information collected and reported, including geologic descriptions, groundwater quality, soil quality, and groundwater movement over time.

3. Individual reports for each of the test holes with appropriate addenda (e.g., lab results, packer/pumping test results and analyses).

4. As-built reports and drawings for all facilities constructed as part of this program.

1.6 REFERENCES

Adrian Brown Consultants, Inc., 1991a, Quality Assurance Project Plan for Kennecott Utah Copper Environmental Actions: Contractor Report to Kennecott Corporation, June, 33 p., 4 appendices.

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Kennecott Corporation, 1984, Report I: Geologic, ground and surface water data background and progress report of Kennecott Utah Copper Division mine hydrogeologic study: Unpublished Report reviewed by the Utah Groundwater Technical and Advisory Group, June, 45 p., 6 appendices.

Kennecott Corporation, 1985, Report II: Annual progress report for 1984-85 joint Kennecott Utah Copper Division mine hydrogeologic study: Unpublished Report reviewed by the Utah Groundwater Technical and Advisory Group, June, 21 p., 3 appendices.

Kennecott Corporation, 1986, Report III: Annual progress report for 1985-86 joint Kennecott Utah Copper Division mine hydrogeologic study: Unpublished Report reviewed by the Utah Groundwater Technical and Advisory Group, June, 28 p., 9 appendices.

Kennecott Corporation, 1987, Report IV: Annual progress report for 1986-87 joint Kennecott Utah Copper Division mine hydrogeologic study: Unpublished Report reviewed by the Utah Groundwater Technical and Advisory Group, June, 34 p., 12 appendices.

Kennecott Corporation, 1988, Report V: Annual progress report for 1987-88 joint Kennecott Utah Copper Division mine hydrogeologic study: Unpublished Report reviewed by the Utah Groundwater Technical and Advisory Group, September, 33 p., 5 appendices.

2.0 FIELD SAMPLING PLAN

2.1 BACKGROUND

The sources of groundwater contamination in the Bingham Creek area were investigated in detail in the "Five Year Study" during the period 1983-1988 (Kennecott, 1984-88). From this study it was determined that groundwater contamination along the Eastside dumps may be the result of seepage losses from the dump leach system, seepage through mine rock dumps and tailings, acid drainage from mineralized rock, and/or seepage through a variety of other surface facilities in the vicinity of Bingham Creek.

In order to determine the extent and sources of contamination, a drilling program has been designed to obtain specific information with respect to the geologic framework, hydrology and hydraulics, and solid and water chemistry of the Eastside area.

2.2 OBJECTIVES

The objectives of the Eastside investigation are:

1. To complete the understanding of where potential contaminant sources are contributing to degradation of the groundwater quality east of KUC's mining operations; and

2. To collect adequate information to enable design of any elements of the contaminant containment system not currently in operation.

In order to achieve these objectives, the drilling program has been designed to provide sample data (e.g., water quality data, permeability information) at several different locations and subsurface depths. These activities involve different methods of sampling, analyses and testing.

2.3 PROGRAM

The program comprises a total of 28 pairs of monitoring wells and three oriented core drill holes along the Eastside dump fronts, and 12 monitoring wells at 10 locations in the Bingham Creek Channel area. Methods for drilling, sampling, handling, and analyses are described below and are found in more detail in the Standard Operating Procedures (SOP's) Attachment (Attachment 1).

2.3.1 Monitoring Wells along Eastside Dump Front

The drilled holes will be relatively shallow (about 200 feet) along the dump fronts due to an expected thin alluvial cover and the data objectives. Wells will be completed in alluvium, bedrock, or the alluvium/bedrock interface after evaluation of the likely paths of contaminant transport using information collected during the drilling and testing activities. Each drainage will be monitored by a well pair which will be nested to enable definition of any vertical variation in water chemistry. Proposed well locations are given in Figure 1 and Table 1.

Due to the relatively shallow nature of these wells, drilling will be conducted using reverse-air methods (without the addition of drilling fluids) wherever possible. Reverse-air drilling will be performed with double-walled drill pipe and appropriate bit.

Table 1 - Proposed Well Locations along Eastside Dump Front

Well #	Location	Leach Collection System	Eastern Storm Water Collection System
1	Bluewater I	above	above
2	Bluewater I	below	above
3	Bluewater I/Bluewater II	below	above
4	Bluewater II	above	above
5	Bluewater II	below	above
6	Bluewater II	below	above
7	Bluewater III	above	above
8	Bluewater III	below	above
9	Bluewater II, Bluewater III, Midas, Congor	below	below
10	Bluewater II, Bluewater III, Midas, Congor	below	below
11	Midas, Congor	below	below
12	Unnamed drainage	below	below
13	Unnamed drainage	below	below
14	North Keystone	below	above
15	Keystone Gulch	below	above
16	Keystone Gulch	below	above
17	Keystone Gulch	below	above
18	Keystone Gulch	below	below
19	Copper Gulch	below	below
20	Copper Gulch	below	above
21	Yosemite Gulch	below	below
22	Unnamed	below	above
23	Saint's Rest Gulch	below	below
24	South Saint's Rest Gulch	below	below
25	Castro Gulch	below	below
26	Butterfield I	below	below
27	Olsen Gulch	below	below
28	Butterfield Canyon	below	below

2.3.2 Eastside oriented core holes

Three oriented NQ diameter core holes are to be drilled along the eastside dump front to evaluate the rock fabric and water quality with depth in the bedrock beneath the toe of the dump. These holes will be evenly spaced along the dump, and located in Bluewater I, Midas, and Keystone Gulches. Holes will be inclined at 60 degrees from the horizontal, and will be oriented due east. Each hole will be drilled to a slant depth of 300 feet. Core will be oriented for fabric analysis. Following drilling, each hole will be packer tested for hydraulic conductivity, using appropriate packer systems.

2.3.3 Monitoring Wells in Bingham Creek Channel

Twelve monitoring wells at 10 locations are planned in or adjacent to the Bingham Creek Channel (Figure 2). Investigations are planned to begin near the location of the current barrier well system, which serves as a Bingham Creek Channel cutoff, and progress downstream. Locations for the 12 wells are listed in Table 2 and summarized below.

Table 2 - Proposed Well Locations in Bingham Creek Channel.

Well #	Completion Interval	Location
1	Bedrock	Upstream of latite dike; northside of channel
2	Bedrock	Downstream of latite dike; northside of channel
3	Bedrock	Opposite ABC-07; northside of channel
4	Bedrock	Downstream of latite dike; southside of channel
5	Bedrock	Downstream of latite dike; southside of channel
6	Bedrock	Downstream of latite dike; southside of channel, paired with ABC-07
7	Bedrock	Downstream of latite dike; southside of channel; between P248 and ABC-01
8,9	Bedrock/Alluvium	Opposite ABC-07; center of channel
10/11	Bedrock/Alluvium	Downstream of P248; center of channel
12	Bedrock	Center of channel; pair of GB-2

2.4 DRILLING METHODS

2.4.1 Alluvial Wells

The following provides an outline of the procedures for alluvial well drilling, completion and data collection:

1. Install surface casing. Drill 12" hole to 10 feet (or deeper if loose conditions require it). Log drill cuttings continuously and collect and bag a sample every five feet. Install 7-inch permanent steel surface casing, and grout into place.

2. Drill to bedrock. Drill a 6 1/2-inch hole to competent bedrock by the reverse-air method. Log drill cuttings continuously and collect and bag a sample every five feet. Collect a water sample each 20 feet, and measure conductivity, temperature, and pH of water every 10 feet.

3. Perform geophysical logging of alluvium. When well is at total depth, run mud into hole. Log hole using the following tools: gamma ray, neutron, density, induction, micro-resistivity, spontaneous potential, caliper, temperature, and sonic logger. This step may be omitted with the approval of

the project director if a clean hole is more desirable than the log information.

4. Complete well. Install casing string comprising 2-inch diameter PVC casing to total depth, with 10 feet of PVC well screen and end cap at base of screen. Install approximately 15 feet of silica sand around screen, using a tremmie pipe. Seal annulus with Pure-Gold bentonite to within 5 feet of the surface, using a tremmie pipe. Cement upper 5 feet of hole and install protective casing and locking cap. After completion, geophysically log through the casing using the following tools: gamma, neutron, induction, and temperature.

8. Develop well. Air lift a total of at least three well volumes of water from well. Monitor conductivity and turbidity, and cease air-lifting when water produced has constant conductivity and is free of visible turbidity.

9. Sample water. After development, take a water sample by purging a further three pore volumes of water from well, and sample using Standard Operating Procedure.

10. Test hydraulic conductivity. After sampling, the well will be tested for hydraulic conductivity using either a slug test or a rising head test after sampling. These tests are described in the Standard Operating Procedures.

2.4.2 Bedrock Well Drilling

The following provides an outline of the procedures for bedrock well drilling and completion, and data collection:

1. Drill to bedrock and case. Drill a 12-inch hole to competent bedrock by the reverse-air method. Log drill cuttings continuously and collect and bag a sample every five feet. Collect a water sample each 20 feet, and measure conductivity, temperature, and pH of water every 10 feet. Install 7-inch permanent steel casing, seat in bedrock, and grout into place.

2. Drill and test rock. Drill a 6 1/2-inch hole approximately 100 feet into competent bedrock by the reverse-air method. Log drill cuttings continuously and collect and bag a sample every five feet. Collect a water sample each 20 feet, and measure conductivity, temperature, and pH of water every 10 feet.

3. Test hydraulic conductivity. Run inflatable packer tool and test hydraulic conductivity of rock portion of hole in two segments, each 40 feet long.

4. Perform geophysical logging of alluvium. When well is at total depth, run mud into hole. Log hole using the following tools: gamma ray, neutron, density, induction, micro-resistivity, spontaneous potential, caliper, temperature, and sonic logger. This step may be omitted with the approval of the project director if a clean hole is more desirable than the log information.

5. Complete well. Install casing string comprising 2-inch diameter PVC casing to total depth, with 40 feet of PVC well screen and end cap at base of screen. Install approximately 50 feet of silica sand around screen, using a tremmie pipe. Seal annulus with Pure-Gold bentonite to within 5 feet of the surface, using a tremmie pipe. Cement upper 5 feet of hole and install protective casing and locking cap. After completion, geophysically log through the casing using the following tools: gamma, neutron, induction, and temperature.

6. Develop well. Air lift a total of at least three well volumes of water from well. Monitor conductivity and turbidity, and cease air-lifting when water produced has constant conductivity and is free of visible turbidity.

7. Sample water. After development, take a water sample by purging a further three pore volumes of water from well, and sample using Standard Operating Procedure. Further sampling will be conducted as part of ongoing KUC monitoring program.

8. Test hydraulic conductivity in completed interval. After sampling, the well will be tested for hydraulic conductivity using either a slug test or a rising head test after sampling. These tests are described in the Standard Operating Procedures.

2.4.3 Oriented Core Drilling

The following provides an outline of the procedures for oriented core drilling and data collection:

1. Drill to bedrock and case. Drill a 6 3/4-inch hole to competent bedrock by mud rotary method. Log drill cuttings continuously and collect and bag a sample every five feet.

Install 4-inch permanent steel casing, seat in bedrock, and grout into place.

2. Drill and test rock. Drill a NQ size hole 300 feet into competent bedrock by diamond coring. Orient core using Standard Operating Procedure. Geologically and geotechnically log core, and store continuous core in core boxes. Photograph each core box using color slides.

3. Test hydraulic conductivity. After drilling is complete, clean hole with water, and run inflatable packer tool and test hydraulic conductivity of full rock portion of hole in 40 feet long segments. Test method shall be using rising head test. During each test express a water sample using air lift, and collect. Test conductivity, pH, and temperature on site. Water sample protocol shall follow water sampling Standard Operating Procedure.

4. Perform geophysical logging of rock. Run mud into hole. Log hole using the following tools: gamma ray, neutron, density, induction, micro-resistivity, spontaneous potential, caliper, temperature, and sonic logger. This step may be omitted with the approval of the project director if a clean hole is more desirable than the log information.

5. Complete well. Cement hole to full depth using neat cement grout.

2.5 SAMPLING METHODS

2.5.1 Sample location and frequency

Several different sample types will be collected during the course of the drilling investigation, such as:

1. Drill cuttings.

2. Formation water - field parameters (during drilling).

3. Formation water - chemical analysis (during drilling).

4. Formation water - at the end of well development.

The frequency for collection of the various samples are as follows:

1. Drill cuttings will be collected every five feet.

2. Formation water field parameters will be measured every five feet.

3. Water samples will be collected every twenty feet and after well development.

2.5.2 Sample designation

All samples collected will be numbered in a manner consistent with previous drilling. Samples will be identified by the hole number, the depth, W for water samples, and the sample date. Solid sample numbers will appear the same, except will not include the letter W.

2.5.3 Sampling equipment and procedures

Each sample type will require specific equipment and procedures, which are outlined in various SOP's. The following provides a list of SOP's which specifically deal with collection of the various sample types:

1. SOP-100: Collection and handling of drill cuttings: Mud-rotary

2. SOP-101: Collection and handling of drill cuttings: Reverse-air

3. SOP-102: Collection and handling of drive samples

4. SOP-103: Collection of groundwater samples for analysis

5. SOP-104: Preparation of water samples for analysis

6. SOP-105: Solid sample splitting

2.5.4 Sample handing and analysis

Sample handling for each of the anticipated sample types is discussed in the SOP's listed above. Sample handling will include bagging, transportation, splitting, routing, and storage.

2.5.5 Sample Paperwork

Traffic reports. Traffic reports will not be used in this project. Chain of custody forms will be used to track the progress of the various samples.

Chain of custody form. A chain of custody form will be used in all circumstances.

SAS packing list. SAS packing list does not apply to this program.

Sample tags. Sample tags consistent with the previous drilling program will be used. The specific labeling procedures are outlined in the various SOP's.

2.6 PERMEABILITY TESTING

Each permeability test (e.g., pumping, packer, slug) will require specific equipment and procedures, which are outlined in various Standard Operating Procedures (SOP). The type of permeability test to be run will be dependent on data collected during the drilling activities.

The following provides a list of SOP's which specifically deals with the permeability testing procedures:

1. SOP-200: Permeability testing: Slug test.
2. SOP-201: Permeability testing: Packer tests.
3. SOP-202: Permeability testing: Pumping tests.

These SOP's will be provided in a Quality Assurance Program Plan. These SOP's may be modified to reflect specific requirements of this program.

2.7 GEOPHYSICAL BOREHOLE LOGS

Geophysical borehole logs will be run in each test hole. A list of these logs is given below:

Open hole: gamma ray, neutron, density, induction, micro-resistivity, spontaneous potential, caliper, temperature, and sonic.

Cased hole: gamma ray, induction, and neutron.

2.8 DELIVERABLES

A well report will be produced for each well drilled, and will include the following:

- Purpose of the well
- Description of the drilling and completion activities
- Geologic description and pictorial log of the hole
- Geophysical logs of the hole (if any)
- Description of the sampling performed
- Results of sampling/testing at the well site
- Results of laboratory testing (when available)
- Results of any hydraulic testing

3.0 QUALITY ASSURANCE PROJECT PLAN

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- Project Organization and Responsibilities
- Quality Assurance Objectives
- Sampling Procedures
- Sample Custody
- Calibration Procedures
- Analytical Procedures
- Data Reduction, Validation, and Reporting
- Internal Quality Control
- Performance and Systems Audit
- Preventative Maintenance
- Data Assessment Procedures
- Corrective Actions
- Quality Assurance Reports

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- Organization
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- Employee Training
- Personal Protective Equipment
- Medical Surveillance Requirements
- Site Monitoring Requirements
- Site Control Measures
- Decontamination Procedures
- Standard Operating Procedures for the Site
- Site Contingency Plan
- Entry Procedures for Confined Spaces

PROJECT PLANS
FOR
LARGE BINGHAM RESERVOIR
SOURCE CONTROL

SALT LAKE COUNTY, UTAH

Report 1212Q/910624
June 24, 1991
Printed: June 27, 1991 9:40pm

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1.0 OVERALL WORKPLAN

1.1 INTRODUCTION/BACKGROUND STATEMENT

The Large Bingham Reservoir is located to the east of Copperton. The reservoir was constructed in 1965, and since that time has stored acid and metal-bearing water as part of the stormwater management system of the Kennecott Utah Copper's Bingham Operation. The reservoir has been determined to leak leach water stored in it to the groundwater system. To prevent this leakage, Kennecott has undertaken an extensive program to address surface and groundwater control in the Bingham Mine area. The lining of the reservoir is necessary in order to meet regulatory requirements and to prevent further groundwater contamination.

The lining of the Large Bingham Reservoir is the final stage in a multi-phased program. The program was initiated in 1987 after a three-year study and in response to more stringent requirements of state and federal environmental regulatory agencies.

Phase I of the program was completed in 1987 and provided a partial control measure by construction of diversion facilities and lined storage ponds on existing mine waste dumps.

Phase II completed the separation of uncontaminated runoff water from the upper canyons and Bingham Tunnel for transport directly into the process water reservoir at the Copperton Concentrator. Mildly contaminated runoff water is piped from the mine to a new water treatment plant, at Copperton, and through the tailings pipeline to the Magna tailings impoundment and recycled to the milling process.

Phase III is in progress and includes the lining of the small Bingham Reservoir for use in isolating, containing and recirculating excess leachate solution from the Bingham waste dump leaching operation. Phase III includes a pumphouse below the Large Bingham Reservoir and a disposal pipeline to transport excess runoff water from the reservoir to the Copperton Treatment Plant and the tailings system where it may be recycled to the process.

Details of the current and future construction of the Large Bingham Reservoir is presented in Figure 1.

1.2 OBJECTIVES

The objective of the proposed environmental response program is to assure that no acid or metal-bearing water can seep from the Large Bingham Reservoir to the groundwater system.

1.3 SCOPE

The proposed approach to eliminate seepage of acid water from the Large Bingham Reservoir is to line the necessary capacity (460 acre feet) with 12 inches of clay and with plastic (HDPE). The implementation of the proposed action comprises the following:

1. Reservoir Construction. The construction of the reservoir facility requires the following steps:

    - Preparation of the area around the reservoir, including road construction, grading of side slopes, and construction of a fence around the facility.

    - Dewatering of the reservoir, with water being pumped to the Copperton Concentrator for discharge to the Magna Tailings facility.

    - The present reservoir will be divided into two nearly equal units by the construction of a second dam, the upstream portion of which will have the capacity for 460 acre-feet.

    - Removal or in-situ stabilization of leach liquor sludge (principally iron oxide and carbonates) from within the intermediate reservoir basin (460 acre-feet), mixing with sand to render it solid, and disposal in a prepared area on the eastside waste rock dumps.

    - Removal or in-situ stabilization of relic copper tailings from within the intermediate reservoir, and disposal in either the waste rock dump or the Bluewater I repository.

    - Backfilling portions of the intermediate reservoir basin to create a surface suitable for placement of the liner.

2. Reservoir Lining. The lining of the intermediate reservoir will require the following steps:

- Placement of a 12" clay liner over the prepared reservoir basin surface. This liner will be compacted to a permeability of 10^{-7} cm/sec.

- Placement of a 60 mil (0.060") HDPE liner over the reservoir basin, covering the clay liner and the leach detection system.

3. <u>Miscellaneous Structures</u>. There are a number of miscellaneous structures which are required to allow the construction of the reservoir, which will be constructed as part of this proposal:

   - Valved reservoir inlet structure for control of water from the existing 100 acre foot silt control coffer dam.

   - Additional concrete structures for diversion of water during construction, including the coffer dam interface, emergency diversion canal, bypass line, and Small Bingham Reservoir overflow system.

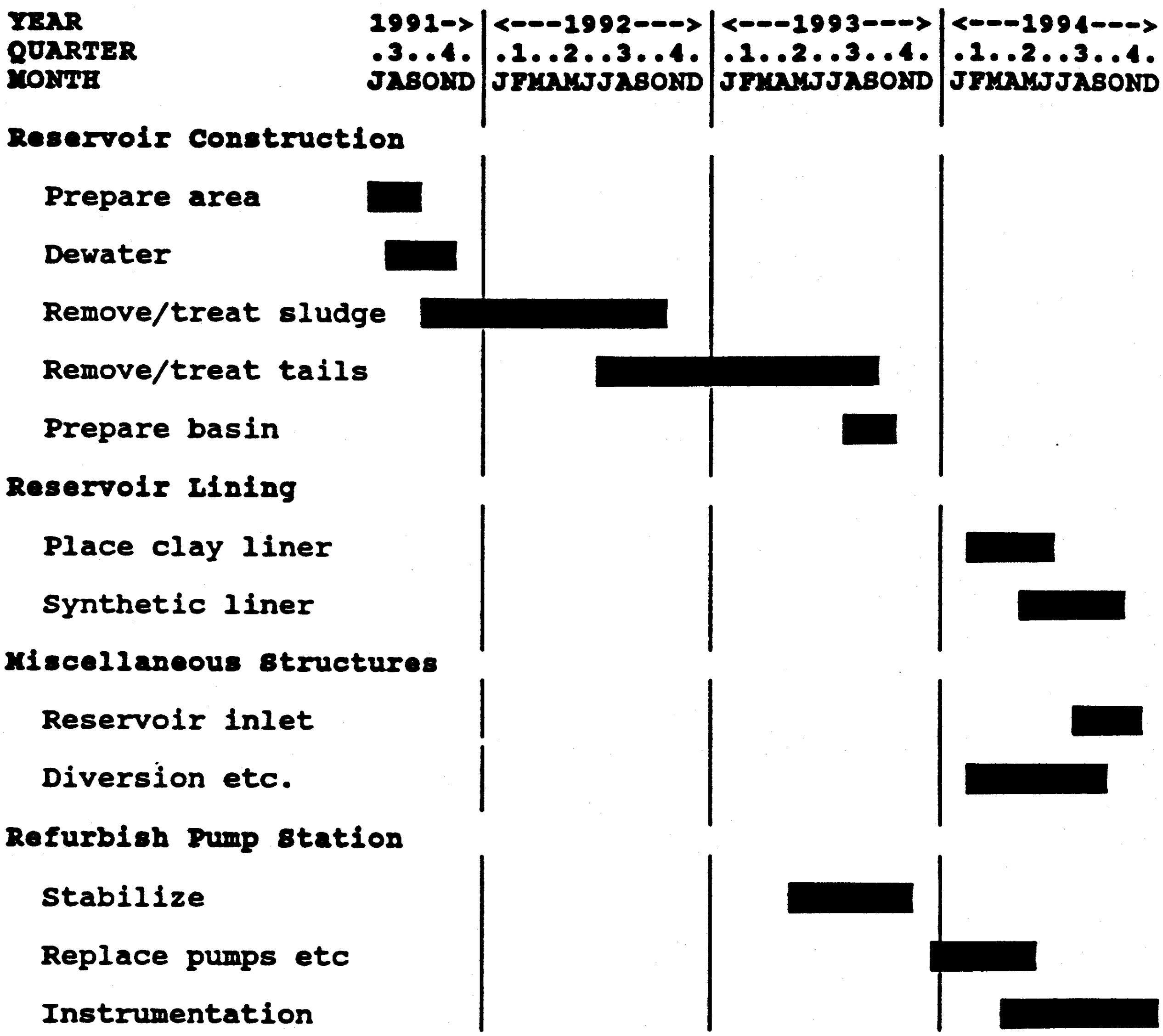
4. <u>Pump Station Refurbishing</u>. The existing vertical pump station will require a significant amount of refurbishing for efficient operation:

   - Stabilization of the foundations of the station, and strengthening of the structure.

   - Replacement and upgrading of pumps, piping, and valves.

   - Installation of instrumentation and monitoring equipment required for operation of the facility under the new Water Management Control System.

1.4 WORK SCHEDULE



1.5 DELIVERABLES

The deliverables for the project will be as follows:

1. Plans for the construction of the reservoir.

2. Removal of reservoir water, removal of sludge, removal of tailings, and construction of the new reservoir.

3. As-built plans of constructed facility.

1.6 REFERENCES

Adrian Brown Consultants, Inc., 1991a, Quality Assurance Project Plan for Kennecott Utah Copper Environmental Actions: Contractor Report to Kennecott Corporation, June, 33 p., 4 appendices.

Adrian Brown Consultants, Inc., 1991b, Health and Safety Plan for Kennecott Utah Copper Environmental Actions: Contractor Report to Kennecott Corporation, June, 14 p., 2 appendices.

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PROJECT PLANS
FOR
BUTTERFIELD WASTE ROCK
REMOVAL ACTION

SALT LAKE COUNTY, UTAH

Report 12120/910626
June 26, 1991
Printed: June 27, 1991 9:42pm

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1.0 OVERALL WORKPLAN

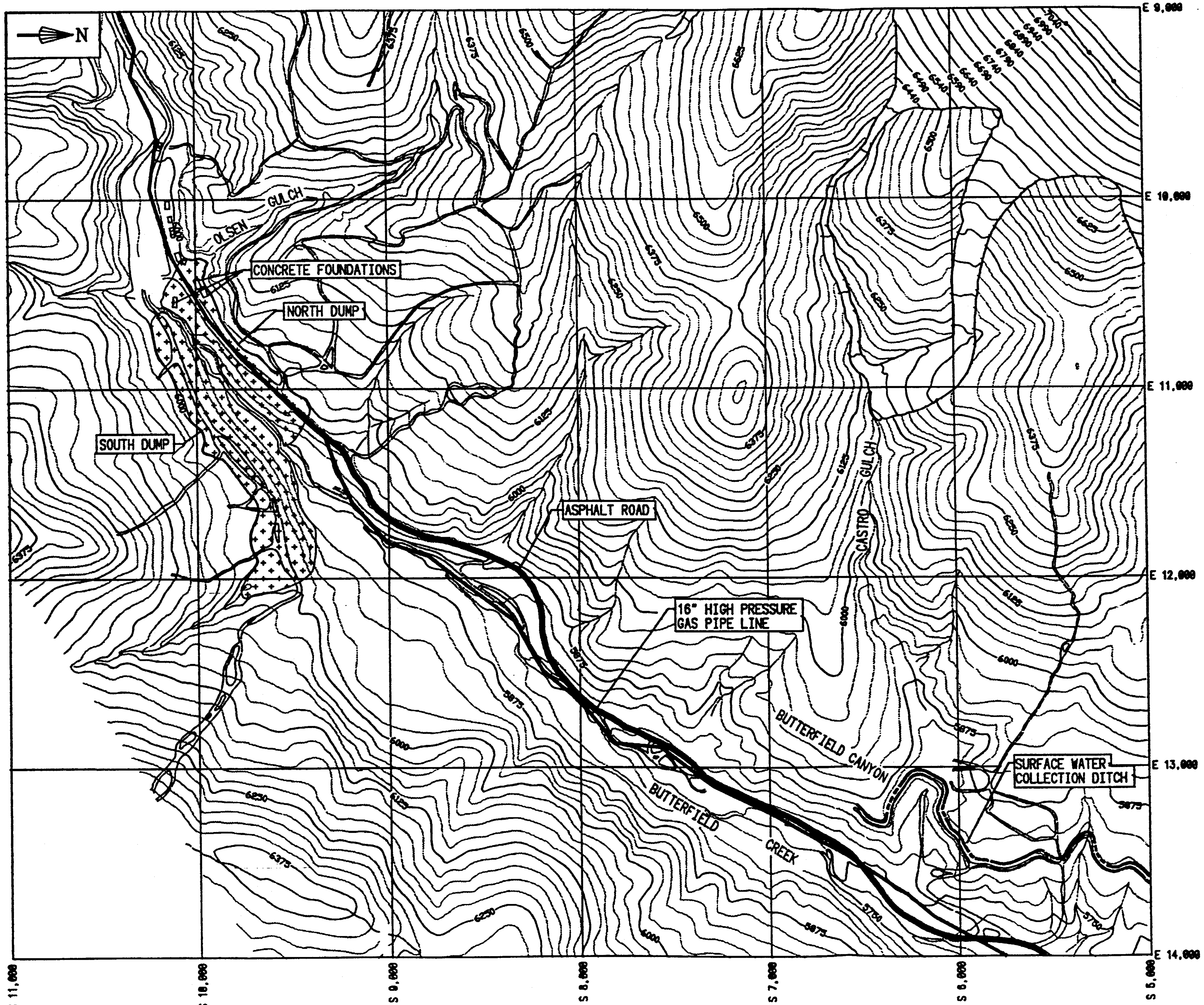
1.1 INTRODUCTION/BACKGROUND STATEMENT

The Butterfield Waste Rock Site is located in Butterfield Canyon (Section 12, T. 4 S., R. 3 W.) approximately three miles west of the town of Lark, in the southwest portion of Salt Lake County, Utah (Figure 1). This site is located in an otherwise undeveloped area adjacent to the Camp Williams State Military Reservation. The area is sparsely populated, with less than 600 people living within a four mile radius of the Butterfield site (EPA, 1990).

The waste rock dumps were produced during the construction of the Butterfield Drainage Tunnel and subsequent mining operations. The tunnel was originally driven by the Combined Metals Reduction Company in about 1912 to drain the Butterfield Mine workings in Galena Gulch, an upper tributary of Bingham Creek. The mine operated until about 1952, producing lead ores that were processed outside of Butterfield Canyon. In the 1950's, the Combined Metals Reduction Company went bankrupt and dissolved. Kennecott currently owns the site, but has never operated the Butterfield Mine. There are no future plans to operate at this location.

The waste rock dumps contain a relatively small amount of material (approximately 1.4 million tons), occupying approximately 15 acres. Downstream from the mine, there are an additional 51,000 cubic yards (75,000 tons) of waste rock and tailings along Butterfield Creek. The dumps were constructed by end-dumping from the mine adit across Butterfield Creek, then along the side of the valley parallel to the Creek. The waste rock extends from elevation 6040 feet (AMSL) at the mouth of the tunnel downstream about 2000 linear feet to elevation 5960 feet. The canyon is steep sided (i.e., total relief in the valley near the mine dumps is approximately 1000 feet), and the waste rock at the toe extends up the canyon about 100 feet above the normal flood stage of Butterfield Creek. Butterfield Creek is a perennial stream; stream flow is ordinarily on the order of 1 to 5 cfs (EPA, 1990).

The waste dumps appear to be moderately to highly oxidized. Total metal content of the material in the Butterfield waste rock has been evaluated by Kennecott (Swensen, 1981). Two samples of the waste rock were analyzed in June 1990 (Strachan, 1990). Results from tests conducted on these samples showed very limited leachability of the metals, indicating that there is no technical



LEGEND

- 16" HIGH PRESSURE GAS PIPELINE
- SURFACE WATER COLLECTION DITCH
- ASPHALT ROAD
- DIRT ROAD
- BINGHAM MINE WASTE DUMP
- BUTTERFIELD MINE WASTE DUMP

NOTE:
TOPOGRAPHY DERIVED FROM "1990" AERIAL MAP.

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SCALE IN FEET

KENNECOTT UTAH COPPER		
BUTTERFIELD MINE WASTE DUMPS EXISTING CONDITIONS		
Date 5/07/91	Dwg. No. 451-T-451	0

basis for considering the solid materials to be hazardous. The analyses also show that, whereas the materials do contain some reactive sulfide, they are not significant acid producing materials (ASCI/ABC, 1990). Based on the EPA Method 1312 leaching tests reported by ASCI/ABC (1990), there is very limited potential for significant releases to ground or surface water from the waste dumps.

Migration of waste materials by air is limited to particulates from the waste rock dumps on site. Because the site materials are rock, little or no airborne dispersion of materials is to be expected, and none has ever been observed (EPA, 1990). No air monitoring stations are present within the nearby vicinity of the site, and are not warranted due to the nature of the waste.

To avoid any potential hazard to recreational users of the canyon and to avoid any water quality degradation to the stream, Kennecott plans to relocate the waste rock outside the stream bed within the collection system containment area and reclaim the Butterfield Waste Rock site for open land use.

1.2 OBJECTIVES

Because the location of these materials is in an active stream channel, the material has the potential to impact the stream's water quality (e.g., additional sediment load). The objective of this project is to minimize this potential impact. Kennecott plans to relocate the mine waste from the stream bed to a storage facility in the Castro Gulch.

1.3 SCOPE

The scope of this workplan will involve activities pertaining to relocation of the Butterfield waste rock to Castro Gulch. Castro Gulch lies inside the Eastside leach collection system and therefore, any stormwater runoff from this storage facility will be contained within the existing Bingham Canyon Mine stormwater collection system. Due to the nonleachable nature of the waste, lining or capping of the storage facility is not necessary.

Planned actions necessary to move the waste rock are outlined in Sections 1.3.1 and 1.3.2.

1.3.1 Castro Gulch

The following activities will be necessary to establish a disposal area in Castro Gulch:

1. Design the disposal area in Castro Gulch.
2. Construct access road to planned repository (approximately 4500 feet).
3. Clear area of major growth.
4. Construct toe dike at base of repository.
5. Emplace waste rock.
6. Grade and compact the relocated waste dumps.

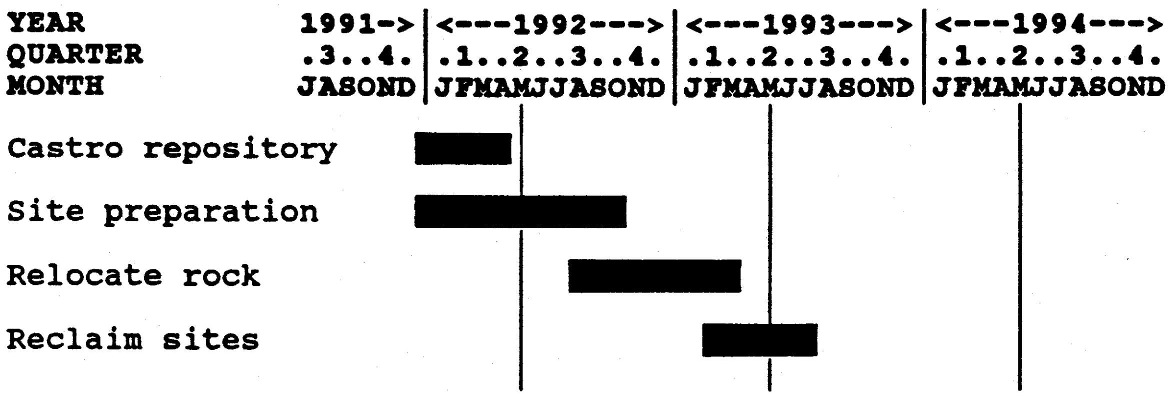
1.3.2 Butterfield Canyon

The following activities will be necessary to relocate the waste rock in Butterfield Canyon:

1. Divert water from the creek and tunnel into a pipeline (approximately 4200 feet of 24-inch HDPE) along the affected area of the canyon.
2. Relocate (approximately 2000 feet) existing 16-inch steel natural gas supply pipeline.
3. Construct sediment collection pond on Butterfield Creek below the work area.
4. Clear work area of brush and trees.
5. Build haulage road between waste dump and Castro disposal area.
6. Relocation of the waste will be accomplished by using a fleet of loaders, backhoes, dozers and trucks.
7. Relocate waste from the south side (Phase I) of the canyon (approximately 725,000 cubic yards).
8. Move water diversion pipeline to modify channel alignment.
9. Relocate waste from the north side (Phase II) of the canyon (approximately 221,000 cubic yards).
10. Relocate miscellaneous deposits (approximately 61,000 cubic yards) presently in the creek channel.
11. Clean and remove sediment pond.
12. Grade and contour work areas.
13. Remove creek diversion pipeline.
14. Recover and replant work area(s) with topsoil and native trees and grasses.

15. Grade and cover new county road (approximately 3500 feet) with road base and asphalt through the work area to the existing paved road.

1.4 WORK SCHEDULE



1.5 DELIVERABLES

The deliverables for the project will be as follows:

1. Project plans and specifications.
2. The removal of the waste rock to a facility on Kennecott Property.
3. An as-built report on the completed disposal site.

1.6 REFERENCES

Adrian Smith Consulting Inc., and Adrian Brown Consultants, Inc., 1990, Initial geochemical evaluation of materials in Butterfield Mine Waste Rock, Contractor report to Kennecott Corporation, October, 8 p. and 2 appendices.

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Strachan, Clint, 1990, Utah Kennecott Corporation Soil Sampling Subtask: Memorandum to Mark Logsdon, Adrian Brown Consultants, Inc.; Water, Waste & Land, Inc., June 21, 3 p., 1 table, figures, and attachments.

Swensen, A.J., 1981, Waste dump sampling project: Interoffice Letter to T.R. Carlson, Kennecott Utah Copper Division, 1 p. and 3 maps.

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PROJECT PLANS
FOR
BUTTERFIELD WASTE ROCK
REMOVAL ACTION

SALT LAKE COUNTY, UTAH

Report 12120/910626
June 26, 1991
Printed: June 27, 1991 9:42pm

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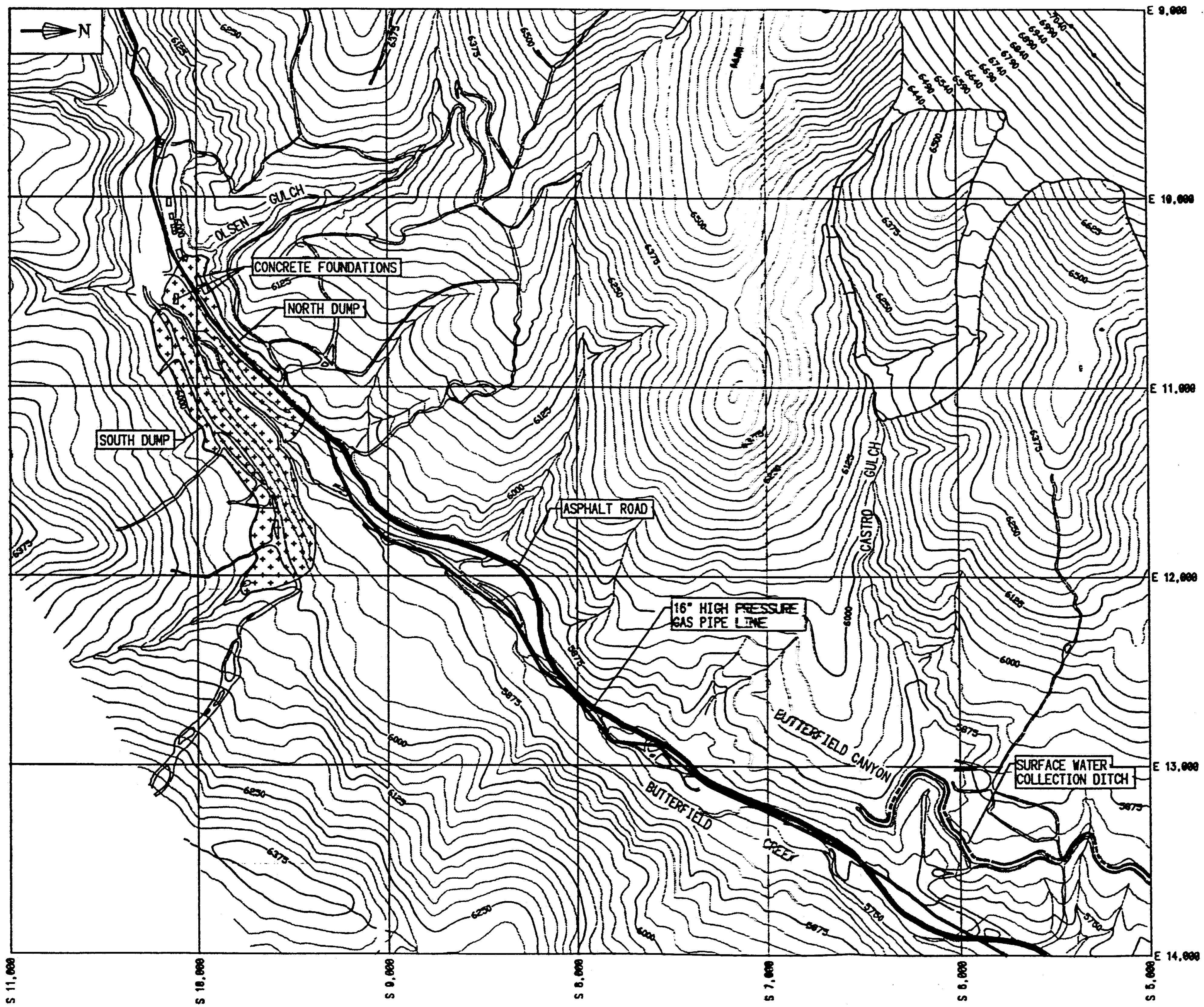

LEGEND

- 16" HIGH PRESSURE GAS PIPELINE
- SURFACE WATER COLLECTION DITCH
- ASPHALT ROAD
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0 500 1000

SCALE IN FEET

KENNECOTT
UTAH COPPER

BUTTERFIELD MINE WASTE DUMPS
EXISTING CONDITIONS

Date 5/07/91	Dwg. No. 451-T-451	Revision 0

6

basis for considering the solid materials to be hazardous. The analyses also show that, whereas the materials do contain some reactive sulfide, they are not significant acid producing materials (ASCI/ABC, 1990). Based on the EPA Method 1312 leaching tests reported by ASCI/ABC (1990), there is very limited potential for significant releases to ground or surface water from the waste dumps.

Migration of waste materials by air is limited to particulates from the waste rock dumps on site. Because the site materials are rock, little or no airborne dispersion of materials is to be expected, and none has ever been observed (EPA, 1990). No air monitoring stations are present within the nearby vicinity of the site, and are not warranted due to the nature of the waste.

To avoid any potential hazard to recreational users of the canyon and to avoid any water quality degradation to the stream, Kennecott plans to relocate the waste rock outside the stream bed within the collection system containment area and reclaim the Butterfield Waste Rock site for open land use.

1.2 OBJECTIVES

Because the location of these materials is in an active stream channel, the material has the potential to impact the stream's water quality (e.g., additional sediment load). The objective of this project is to minimize this potential impact. Kennecott plans to relocate the mine waste from the stream bed to a storage facility in the Castro Gulch.

1.3 SCOPE

The scope of this workplan will involve activities pertaining to relocation of the Butterfield waste rock to Castro Gulch. Castro Gulch lies inside the Eastside leach collection system and therefore, any stormwater runoff from this storage facility will be contained within the existing Bingham Canyon Mine stormwater collection system. Due to the nonleachable nature of the waste, lining or capping of the storage facility is not necessary.

Planned actions necessary to move the waste rock are outlined in Sections 1.3.1 and 1.3.2.

1.3.1 Castro Gulch

The following activities will be necessary to establish a disposal area in Castro Gulch:

1. Design the disposal area in Castro Gulch.
2. Construct access road to planned repository (approximately 4500 feet).
3. Clear area of major growth.
4. Construct toe dike at base of repository.
5. Emplace waste rock.
6. Grade and compact the relocated waste dumps.

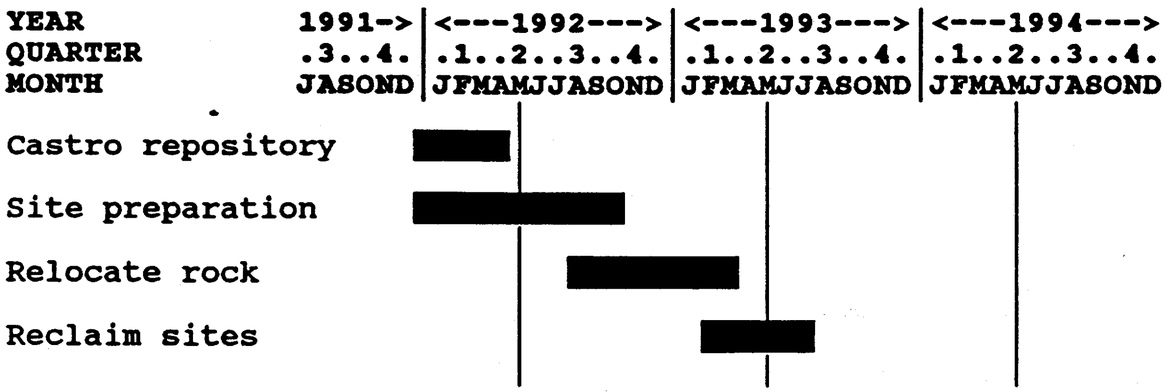
1.3.2 Butterfield Canyon

The following activities will be necessary to relocate the waste rock in Butterfield Canyon:

1. Divert water from the creek and tunnel into a pipeline (approximately 4200 feet of 24-inch HDPE) along the affected area of the canyon.
2. Relocate (approximately 2000 feet) existing 16-inch steel natural gas supply pipeline.
3. Construct sediment collection pond on Butterfield Creek below the work area.
4. Clear work area of brush and trees.
5. Build haulage road between waste dump and Castro disposal area.
6. Relocation of the waste will be accomplished by using a fleet of loaders, backhoes, dozers and trucks.
7. Relocate waste from the south side (Phase I) of the canyon (approximately 725,000 cubic yards).
8. Move water diversion pipeline to modify channel alignment.
9. Relocate waste from the north side (Phase II) of the canyon (approximately 221,000 cubic yards).
10. Relocate miscellaneous deposits (approximately 61,000 cubic yards) presently in the creek channel.
11. Clean and remove sediment pond.
12. Grade and contour work areas.
13. Remove creek diversion pipeline.
14. Recover and replant work area(s) with topsoil and native trees and grasses.

15. Grade and cover new county road (approximately 3500 feet) with road base and asphalt through the work area to the existing paved road.

1.4 WORK SCHEDULE



1.5 DELIVERABLES

The deliverables for the project will be as follows:

1. Project plans and specifications.

2. The removal of the waste rock to a facility on Kennecott Property.

3. An as-built report on the completed disposal site.

1.6 REFERENCES

Adrian Smith Consulting Inc., and Adrian Brown Consultants, Inc., 1990, Initial geochemical evaluation of materials in Butterfield Mine Waste Rock, Contractor report to Kennecott Corporation, October, 8 p. and 2 appendices.

Adrian Brown Consultants, Inc., 1991a, Quality Assurance Project Plan for Kennecott Utah Copper Environmental Actions: Contractor Report to Kennecott Corporation, June, 33 p., 4 appendices.

Adrian Brown Consultants, Inc., 1991b, Health and Safety Plan for Kennecott Utah Copper Environmental Actions: Contractor Report to Kennecott Corporation, June, 14 p., 2 appendices.

EPA, 1986, Test Methods for Evaluating Solid Waste, SW-846, Third Edition, U.S. Environmental Protection Agency, Washington D.C., two volumes.

EPA, 1988, Guidance for conducting remedial investigations and feasibility studies under CERCLA: Interim Final Report, OWSER Directive 9355.3-01, EPA/540/G-89/004, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, October, 120 p., 6 appendices.

EPA, 1990, CERCLA file information, Butterfield Mine, December, 11p.

Kennecott Corporation, 1991, Kennecott Utah Copper Environmental Response, Lark Waste Rock (CERCLIS title: Lark Tailings), April 11.

Strachan, Clint, 1990, Utah Kennecott Corporation Soil Sampling Subtask: Memorandum to Mark Logsdon, Adrian Brown Consultants, Inc.; Water, Waste & Land, Inc., June 21, 3 p., 1 table, figures, and attachments.

Swensen, A.J., 1981, Waste dump sampling project: Interoffice Letter to T.R. Carlson, Kennecott Utah Copper Division, 1 p. and 3 maps.

3.0 QUALITY ASSURANCE PROJECT PLAN

A standard quality assurance program will be developed for the specific needs of this work plan. The plan will contain the following elements:

- Project Description
- Project Organization and Responsibilities
- Quality Assurance Objectives
- Sampling Procedures
- Sample Custody
- Calibration Procedures
- Analytical Procedures
- Data Reduction, Validation, and Reporting
- Internal Quality Control
- Performance and Systems Audit
- Preventative Maintenance
- Data Assessment Procedures
- Corrective Actions
- Quality Assurance Reports

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A standard health and safety plan will be developed for the specific needs of this work plan. The plan will contain the following elements:

- Organization
- Health and Safety Risk Analysis
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- Personal Protective Equipment
- Medical Surveillance Requirements
- Site Monitoring Requirements
- Site Control Measures
- Decontamination Procedures
- Standard Operating Procedures for the Site
- Site Contingency Plan
- Entry Procedures for Confined Spaces

PROJECT PLANS
FOR
DIVING BOARD AREA
REMOVAL ACTION

SALT LAKE COUNTY, UTAH

Report 1212E/910624
June 24, 1991
Printed: June 27, 1991 10:01pm

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1.0 OVERALL WORK PLAN

1.1 INTRODUCTION/BACKGROUND STATEMENT

The Diving Board Area is located just to the north of the Magna Concentrator, to the southwest of the Town of Magna, and to the east of the Magna Tailings Pond. The area has served for many years as a temporary storage location for tailings and other overflow materials associated with the tailings pond and concentrator operation. It takes its name from the presence of a cyclone jumbo which has been utilized in the area to produce sands for road construction. The cyclone jumbo bears some resemblance to a large diving board.

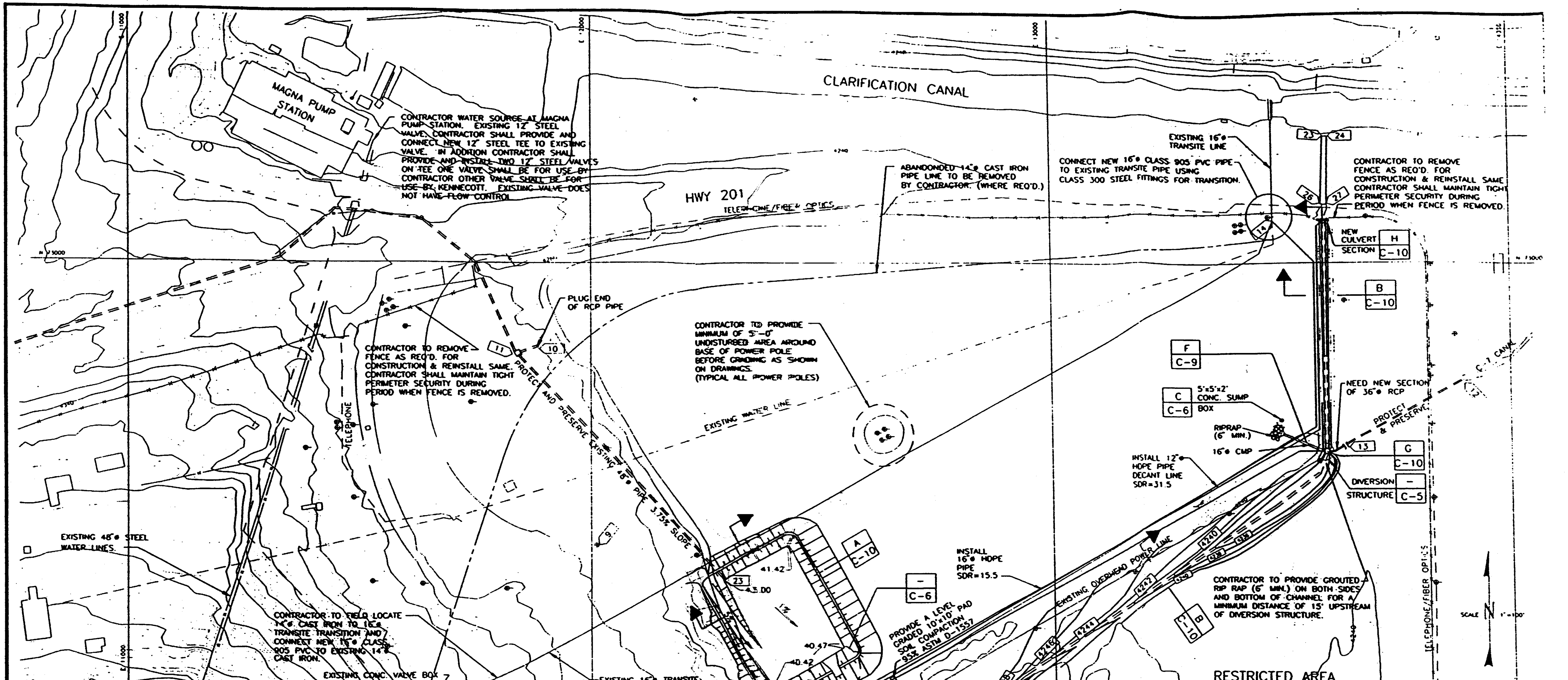
1.1.1 Function

The Diving Board Area consists of an 8-acre northern impoundment and a 13-acre southern impoundment (Figure C-4). The 21-acres of impoundment are utilized to impound tailings overflow during periods of scheduled and emergency shut down, and to control and direct a variety of both process and non process water streams which occur in this area.

Discharges to and from the impoundment are summarized below:

1. Whenever flow in the Magna Tailings Pond discharge system is interrupted, the delivery pipe has to be emptied. To achieve this, the line is drained at the Magna Pump House (the low point in the line) and the resulting tailings slurry is discharged through a concrete pipe which connects the pump house to the Diving Board Area. A concrete junction box at the west end of the Diving Board Area is utilized to divert the tails to either of the two impoundments. Approximately 1500 dry tons of tailings per month has drained in this manner.

2. Mill Waters, consisting of overflow from the Magna Thickeners and excess waters from the Magna reservoir, are diverted and captured in the Diving Board Area. Overflow is temporarily captured in two surface impoundments northwest of the Magna thickener tanks, and is then diverted under the 2100 South highway in a 16" culvert which, in turn, discharges to a ditch feeding into the Magna pump house concrete discharge line.



NUMBER	COORDINATES NORTH	EAST	ELEVATION	DESCRIPTION
1	72862 890	13571.440	4248.11	CONTROL POINT REBAR W/CAP
2	72651.180	11722.670	4287.57	CONTROL POINT REBAR W/CAP
3	72731.490	13901.530	4236.29	CONTROL POINT REBAR W/CAP
4	71992 170	11643.656		SE CORNER BONNEVILLE PUMP HOUSE
5	72019 685	11629.027		NE CORNER BONNEVILLE PUMP HOUSE
6	72009.769	11610.183		NW CORNER BONNEVILLE PUMP HOUSE
7	72025 969	11619.907		POINT ON 14"⌀ CAST IRON WATER LINE
8	72057 280	11670.356		POINT ON 14"⌀ CAST IRON WATER LINE
9	72386.751	12011.237		POWER SOURCE
10	72820 59	11887 62	4252.69	END OF EXISTING, 48"⌀ RCP, FL ELEV.
11	72804.36	11844 74	4268.56	CENTER POINT OF CONC JUNCTION BOX
12	72744 82	13897.15	4230.07	END OF EXISTING 36"⌀ PIPE, IE
13	72605 165	13652.485	4230.66	END OF EXISTING 36"⌀ PIPE, IE
14	72798 1	12573 4		MONITORING WELL 605A
15	72788 4	12577.2		MONITORING WELL 605B
16	72883 2	13565.1		MONITORING WELL 602A
17	72880 2	13553 6		MONITORING WELL 602B
18	72323 2	13113 1		MONITORING WELL 604A
19	72317 5	13102.9		MONITORING WELL 604B
20	71300.0	12380.0		TAILING REMOVAL POINT
21	72628 0	13613 04		TAILING REMOVAL POINT
22	72600.0	13613.04		TAILING REMOVAL POINT
23	72317.65	12292.29	4247.07	END OF EXISTING 48"⌀ RCP, IE
24	73274 41	13618.51		NE CORNER EXISTING CULVERT BOX
25	73274 57	13607.57		NW CORNER EXISTING CULVERT BOX
26	73126 64	13601 20		SW CORNER EXISTING CULVERT BOX
27	73126 64	13615.00		SE CORNER EXISTING CULVERT BOX
28	72015 30	12495 05	4242.63	END OF 16"⌀ HDPE PIPE, I.E

NO | REVISIONS | BY | DATE

DRAWN FRP 4/91 CHECKED
DESIGNED
APPROVED

KENNECOTT – UTAH COPPER
MAGNA, UTAH

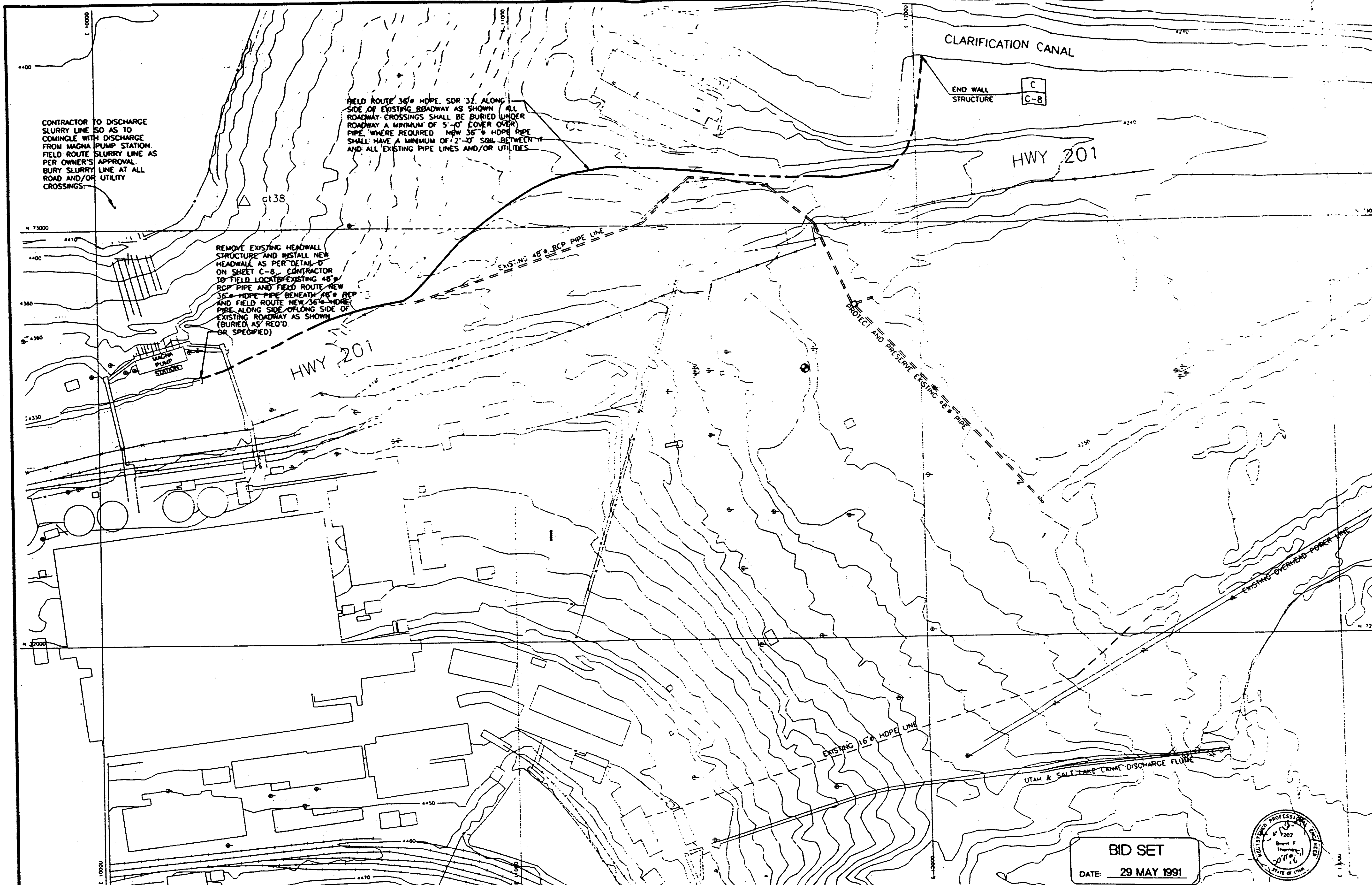
FORSGREN ASSOCIATES / P.A.
SALT LAKE CITY UTAH

DIVING BOARD AREA SEDIMENTATION/DETENTION

SITE LAYOUT PLAN

PROJECT NO 5-91-082

SHEET NO C-2 4



BID SET
DATE: 29 MAY 1991

DRAWN FRP 4/91 CHECKED	KENNECOTT – UTAH COPPER MAGNA, UTAH	FORSGREN ASSOCIATES / P.A. SALT LAKE CITY, UTAH	DIVING BOARD AREA SEDIMENTATION/DETENTION	PROJECT NO. 5-91-082
DESIGNED			SITE PLAN	SHEET NO. C-4
APPROVED				
NO. REVISIONS BY DATE				

3. Excess waters form the Magna Reservoir are diverted to the Diving Board Area through a 16" HDPE pipeline from the Bonneville #3 pumphouse. The HDPE pipeline discharges into the southwest corner of the southern impoundment.

4. Utah and Salt Lake Canal water which is not required for the process circuit are discharged to the Diving Board Area through a concrete flume, and are then diverted through an isolated diversion ditch adjacent to the southern impoundment to control their flows and to prohibit their commingling with decant and process waters.

5. The Diving Board Area also acts as a detention basin for local runoff.

The Diving Board Area currently has two outlets for waters flowing into the area. Due to the gently sloping grade of the Diving Board Area, the eastern end of the Diving Board Area acts to collect and divert decant from the discharged tails and mill water to a return ditch and culvert connected to the clarification canal. Meteoric runoff captured in this area is also diverted to the clarification canal. Waters from the Utah and Salt Lake Channels diverted around the southern edge of the Diving Board Area can be directed to join the process water circuit to the clarification canal or directed to discharge to the C-7 Ditch.

1.1.2 Condition

The Diving Board Area currently contains a total of approximately 450,000 cubic yards of tailing. The water content of the materials in the area ranges from 25% to 55%.

The smaller, 8-acre impoundment to the north has a concrete decant structure on the eastern end and is surrounded by containment dikes constructed of discarded electrolyte cells and tailings. A 16"-transit water line running east-west. This water line is the main water feed for the Magna Plant facilities.

The larger, 13-acre impoundment to the south has a concrete decant constructed at the eastern end of the impoundment. The decant structure has been previously breached. As a result the collection ditch and culvert that diverts the decant and mill waters to the clarification canal is infilled with tails. The containment dikes for the larger impoundment appear to be constructed of both local borrow materials and tails. A 16"-steel water line has been laid adjacent to the outer slope of the southern containment dike. This water line is the main water supply line to the KUC Power Plant. A Plan of the area is presented in Figure C-2, showing the decant structures, impoundments, and the surrounding facilities.

1.1.3 Impacts

The accumulation of tailings in the Diving Board Area has the potential to have an adverse environmental impact. Airborne dust from the Diving Board Area has the potential to affect air quality. Although dust from the facility has the potential to be dispersed by wind into the air, dust generation can be limited by the moisture content of the materials.

Surface water is not adversely affected by the Diving Board Area because stormwater runoff is handled separately from process water which is recirculated. UPDES permit requirements are being met.

1.2 OBJECTIVES

The objectives of the Diving Board removal action are to:

1. Eliminate the possibility of airborne dust from the facility.

2. Segregate the stormwater system from the tailings surge and storage system to prevent any potential degradation of surface water.

3. Contain the tailings in a common facility to improve operations. The construction of a water control structure in the location currently occupied by tailings necessitates removal of the tailings currently in place.

1.3 SCOPE

The actions to be undertaken to achieve the objectives are described below.

1.3.1 Tailings characterization

Because there is no reason to expect the tailings in the Diving Board impoundment are any different from the tailings in the Magna tailings impoundment, no separate analysis of these materials has previously been conducted. The sampling program under this plan will comprise taking 40 samples of tailings and other solid phase materials from around the site, and approximately 6 samples of water from the site area. Samples will be analyzed for EPA Method 1312 leachability. Details of the characterization program are provided in the Field Sampling Plan, Section 2.

Information from this program will be assembled and used in establishing the appropriate method of transport and disposal of the tails.

1.3.2 Site preparation activities

A number of activities will be undertaken to prepare the site:

1. 16" Transit Water line. This line was under the Diving Board Area and supplies water to the Magna Plant facilities. This line will be relocated.

2. 16" Steel Water line. A 16" steel water line is believed to run adjacent to the larger (southern) impoundment. This line will be located using pipe location/detection equipment and if it will conflict with the proposed site structures, it will be relocated.

3. Thickener Overflow Water. The thickener overflow water will be re-routed before they enter the Magna Pump house discharge line and will be re-routed directly to the clarification canal, by-passing the Diving Board Area.

4. Non-Operational Water Control Structure. There is a non-operational water control structure in the vicinity of the Diving Board Area. This structure will be demolished and will

be replaced with an operation control structure. Metal fittings will be recovered for scrap, and the remaining (mainly concrete) materials disposed of in a Kennecott Landfill. Any tailings recovered will be added to the tailings contained within the facility prior to disposal as described below.

5. Diving Board: The Cyclone Jumbo which gives the area its name has been demolished and removed for scrap.

1.3.3 Tailings removal

Tailings materials in and around the area will be removed by the following process:

1. Tailings will be excavated using either backhoe and front-end loader equipment, or by dredging. The areas to be excavated include the tailings storage basin, the diversion ditch, and the clarification canal.

2. Tailings will be verified visually for the purpose of excavation. Samples will be taken from the excavated surface when tailings removal is completed and analyzed for total copper and lead to verify removal. A minimum of 2 samples per acre will be taken for this purpose.

3. The tailings will be transported to the tailings pond as a slurry, with the temporary slurry line running from the Diving Board area to the Magna Point Discharge, where the two tailings streams will be merged. The temporary discharge line will run beneath the highway adjacent to the Diving Board Area.

1.3.4 Control structure construction

Following tailings removal and site regrading, the following construction will take place:

1. A concrete structure will be constructed to allow for the capture of up to 15,000 cubic yards of future tailings discharge from the Magna Pump House under upset conditions. This capacity has been chosen to allow the removal of tailings spillage about twice per year. Tailings material collected in this structure will be periodically removed and deposited in the Magna Tailings Pond.

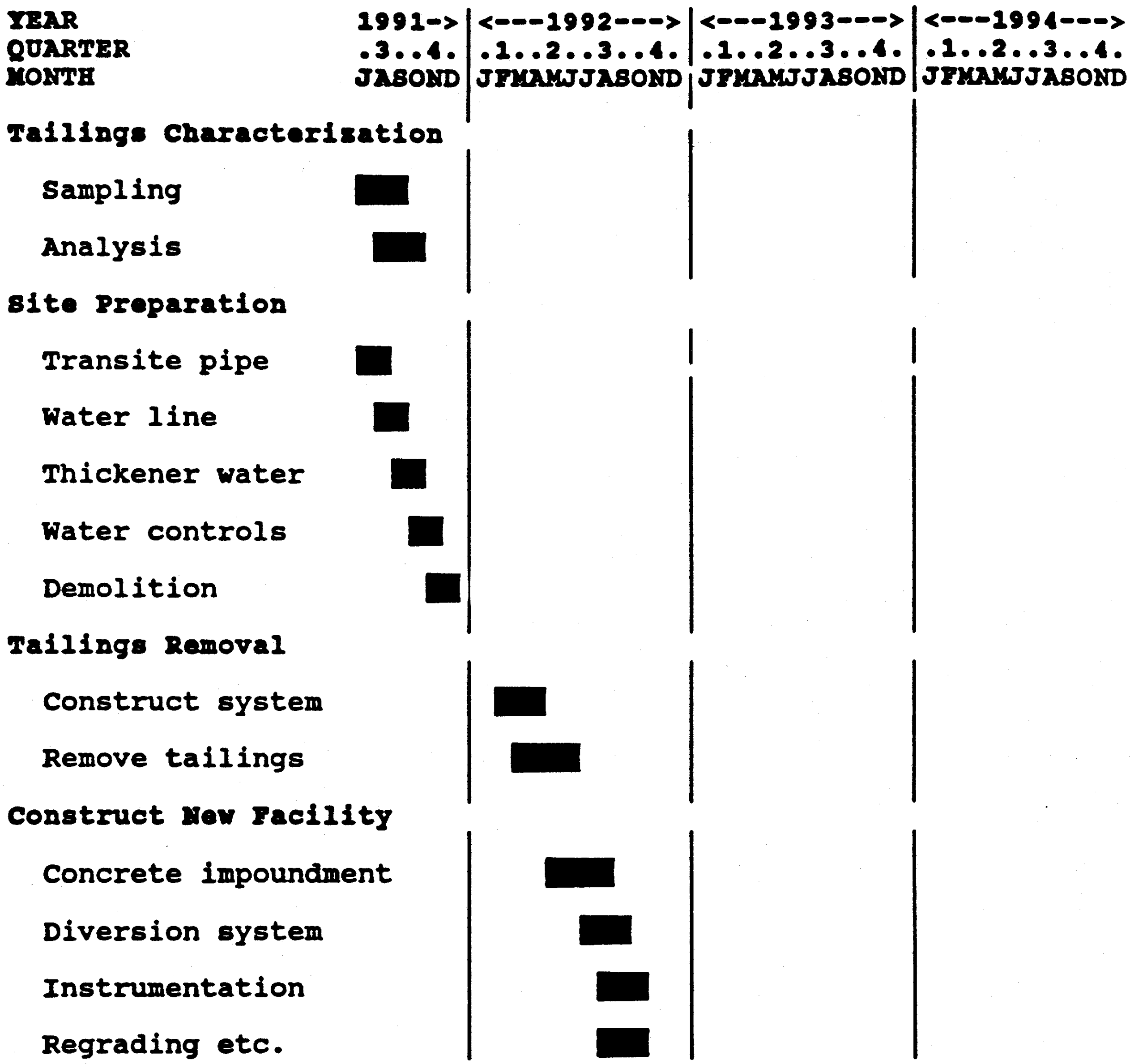
2. A diversion pipe will be constructed to collect decanted liquids, and direct them to the clarification canal to prevent commingling with runoff water or permitted process discharge water.

3. Gated, concrete control structure will be constructed to control both the flows of process water from the Bonneville #3 Pump House and the flows from the Utah and Salt Lake Canal. These flows will be directed to either the clarification canal for recirculation to the process, or, if of acceptable quality, will be diverted to the C-7 ditch for discharge.

4. An additional head structure will also be constructed at the culvert to the clarification ditch to provide positive pressure to the clarification canal.

5. Following these construction activities, the area will be regraded to develop a retention basin for storm water runoff in the area. This will support the general drainage control of the area, and allow further monitoring of the surface water quality.

1.4 WORK SCHEDULE



1.5 DELIVERABLES

The deliverables for this project are:

1. Project plans and specifications.

2. Report on the nature of the tailings, including volume, chemical constituents, and leachability.

3. The removal of tailings and the constructed replacement facility.

4. As-built report on completed structure.

1.6 REFERENCES

Adrian Brown Consultants, Inc., 1991a, Quality Assurance Project Plan for Kennecott Utah Copper Environmental Actions: Contractor Report to Kennecott Corporation, June, 33 p., 4 appendices.

Adrian Brown Consultants, Inc., 1991b, Health and Safety Plan for Kennecott Utah Copper Environmental Actions: Contractor Report to Kennecott Corporation, June, 14 p., 2 appendices.

Forsgren Associates, 1991. Plans and Specifications for the removal of tailings from the Diving Board Area, and the Construction of a Replacement Facility.

2.0 FIELD SAMPLING PLAN

2.1 BACKGROUND

The tailings and other materials in the Diving Board Area are to be removed from the area to allow the facility to be upgraded, facilitate tailings management, and improve the flow system in the area.

2.2 OBJECTIVES

The objective of this sampling program is to evaluate the chemical nature of tailings and other materials in the Diving Board Area.

2.3 TECHNICAL APPROACH

The technical approach is to collect samples from the tailings mass, and from any other material that may be moved as part of this program, and have these samples analyzed for leachable metals. Samples will include tailings, other solid materials, and water. The results of the sampling program will be used to determine the suitability of disposing of the Diving Board tailings, other solids, and liquids at the Magna Tailings Pond.

2.4 SAMPLING METHODS

2.4.1 Sample location and frequency

The sampling location and frequency is as follows:

1. Tailings and other solid materials will be sampled on a grid. A total of 12 sites will be sampled, using a backhoe. Three samples will be taken at each site:

a. An integrated sample over the top 2 feet of the material.

b. An integrated sample over 2 feet, at the halfway point of the deposit thickness, or of the trench, whichever is shallower.

c. An integrated sample over 2 feet, at the bottom of the trench or at the bottom of the deposited materials, whichever is shallower.

In the event that the deposit is less than six feet thick at the sample location, the middle sample will be omitted.

2. In addition, opportunistic samples will be taken at any other location which is found to contain significant quantities of tailings. It is expected that there may be in the order of 10 such locations. A single sample will in general be taken, as a composite of the materials at the selected location. Locations will be selected on site.

   A total of about 40 solid phase samples is expected to be obtained from this program.

3. Water samples will be taken of any significant bodies of standing water. Locations will be selected on site, with about six samples expected to be collected.

2.4.2 Sample designation

The sample designation will be as follows:

DB-NNN-M-TT-BB

where:	DB	= Diving Board identifier
	YY	= Last two digits of year when sampled
	MM	= Number of month when sampled
	DD	= Number of day when sampled
	M	= Medium (S = soil, W = water)
	NNN	= Sample number

A typical soil sample identifier for a sample taken on July 14, 1991, at location 7, mid-depth, would therefore be:

DB007S3-5

2.4.3 Sampling equipment and procedures

Equipment. Necessary equipment will be detailed in the appropriate SOP's.

Procedures. A list of Standard Operating Procedures (SOP's) are given in Table 2. Details of these procedures will be provided in the Quality Assurance Program Plan. These procedures will be followed when conducting any sampling activities.

Table 2. Standard Operating Procedures

Procedure Number		Procedure Title
GENERAL	01	Field Book
GENERAL	02	Sample Custody
GENERAL	02.01	Sample Point Marking and Photographic Evidence Documentation
GENERAL	03	Equipment Maintenance and Calibration
GENERAL	03.01	Field Equipment Maintenance
SOIL	01	Sample Collection
SOIL	02	Sample Documentation
SOIL	03	Sample Container Preparation
SOIL	04	Sample Preservation and Packaging
SOIL	05	Equipment Decontamination

2.4.4 Sample handling

Sample handling for each of the anticipated sample types will be discussed in the SOP's listed above. Sample handling will include bagging, transportation, splitting, routing, and storage.

2.4.5 Sample analysis

Samples shall be analyzed as follows:

1. All solid phase samples will be analyzed for common total metals, and the EPA method 1312 extractable metals. One set of these samples will also be analyzed for natural 1312 chlorinates, hydrocarbons, pesticides, polynuclear groundwater hydrocarbons (PPA's), and PCB's.

2. Water samples will be analyzed for major ions, metals, total petroleum hydrocarbons, and total organic halides, using standard EPA protocols and quality assurance.

2.4.6 Sample Paperwork

<u>Traffic reports.</u> Traffic reports will not be used in this project. Chain of custody forms will be used to track the progress of the various samples.

<u>Chain of custody form.</u> A chain of custody form will be used in all circumstances.

<u>SAS packing list.</u> SAS packing list does not apply to this program.

<u>Sample tags.</u> Sample tags consistent with the previous drilling program will be used. The specific labeling procedures will be outlined in the various SOP's.

2.5 DELIVERABLES

The deliverables for the sampling evaluation task will consist of a final report. The final report of investigations will present all quality assured data obtained in the testing program and will include a technical assessment of the results. The final report will be prepared as a "stand-alone" technical document.

3.0 QUALITY ASSURANCE PROJECT PLAN

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- Entry Procedures for Confined Spaces

PROJECT PLANS
FOR
BINGHAM CREEK GROUNDWATER PLUME
ENVIRONMENTAL ACTION

SALT LAKE COUNTY, UTAH

Report 1212R/910626
June 26, 1991
Printed: June 27, 1991 8:19pm

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1.0 OVERALL WORKPLAN

1.1 INTRODUCTION/BACKGROUND STATEMENT

The primary drainage from the Bingham operations is Bingham Creek, which drains eastward from the Oquirrh Mountains approximately 10 miles to the Jordan River. The Bingham Pit has intercepted what was originally the upper reaches of the creek and, since 1965, the Bingham Reservoir has impounded creek flow at the point where the creek exits the mountains. Excess water collected in the Bingham Pit is treated and pumped to the Magna tailings pond. Water does not flow eastward below the Bingham Reservoir, except during exceptionally large storm events. Most of the runoff water from the Oquirrhs in this zone is contained by a peripheral stormwater and leachate collection system that routes water to a treatment facility. The remainder of the surface water is directed to the Bingham Reservoir system.

Beneath the Bingham Creek Channel, the water table is generally within 200 feet of the surface. The saturated aquifer in this area consists of approximately 100 to at least 800 feet of alluvial sands and gravels, with local interbedded silts and clays. The Jordan Narrows Unit, a clay-rich zone of considerable thickness, underlies the high permeability sands and gravels and appears to form a lower groundwater boundary. Groundwater flow in this alluvial system is east toward the Jordan River and there appears to be little vertical movement (ABC/ASCI, 1990).

Surface and groundwater infiltration into the alluvial fan deposits which extend eastward from the mouth of Bingham Canyon near Copperton has created a plume of acidic, metal-bearing water which covers approximately 1,500 acres downstream from Copperton along Bingham Creek. The groundwater plume has a maximum measured thickness of 100-600 feet and contains an estimated 110,000 acre feet of contaminated water. The plume is currently being actively neutralized by reaction with the alluvium; monitoring of the plume shows little migration of the low-pH, high metals part of the plume during the past five years.

Data collected from Kennecott's plume monitoring system indicates that the area of the plume in which concentrations of metal constituents exceed drinking water standards has receded over the last four to five years (Dames and Moore, 1988). This is due to actions taken by Kennecott to prevent contaminated water from entering the groundwater system (source control), combined with the effects of natural neutralization.

Table 1 shows an analysis of a groundwater sample downgradient from the Bingham Reservoir versus established drinking water standards.

Table 1. Groundwater Quality Downgradient from Bingham Reservoir

	Groundwater Sample	Drinking Water Standards Primary	Drinking Water Standards Secondary
Acidity - pH	3.2		6.5 - 8.5
Other Elements (in parts per million):			
Total Dissolved Solids	45,500		500-3000
Arsenic	22	0.05	
Barium		1.0	
Cadmium	1.22	0.01	
Chromium		0.05	
Copper	60		1.0
Iron	650		0.3
Lead	0.05	0.05	
Magnesium	5280		
Manganese	681		0.05
Selenium		0.01	
Silver		0.05	
Sulfate	30,000		500-1000
Zinc	189		1.0

There is presently no direct human contact with the acid water/heavy metals plume. The contaminated water is not used as a source for drinking water. However, water quality in a few private wells outside the metals plume has been impacted by increased sulfate levels.

1.2 OBJECTIVES

The objective of this remedial program is to develop a more complete understanding of the behavior of the plume, to allow the natural remediation to be adequately understood, and to monitor the effectiveness of the source control program.

1.3 SCOPE

Reaching the objectives of the program requires further investigation into the existing Bingham Creek groundwater plume to establish the extent to which the plume is currently moving, and demonstration of the mechanisms by which the plume is currently remediating itself. The proposed activities are:

1. Performance of geophysical evaluations of the geology of the plume area, for definition and setting of the plume, location of drill holes, and identification of other possible pathways for plume movement. These evaluations will involve seismic reflection, refraction, and resistivity methods.

2. Drilling of a deep geological drill hole in the center of the plume, southeast of the Anaconda Tailings, to establish the geology of the area, the depth to bedrock, and the depth to the top of the low permeability Jordan Narrows clay unit. This hole will also be located so as to calibrate the surface geophysical profiling that is part of the overall program. The hole will be completed with a sealed, non-metallic casing, and will be used to evaluate the feasibility of profiling the water chemistry of the plume from within a completed well, using downhole geophysical tools.

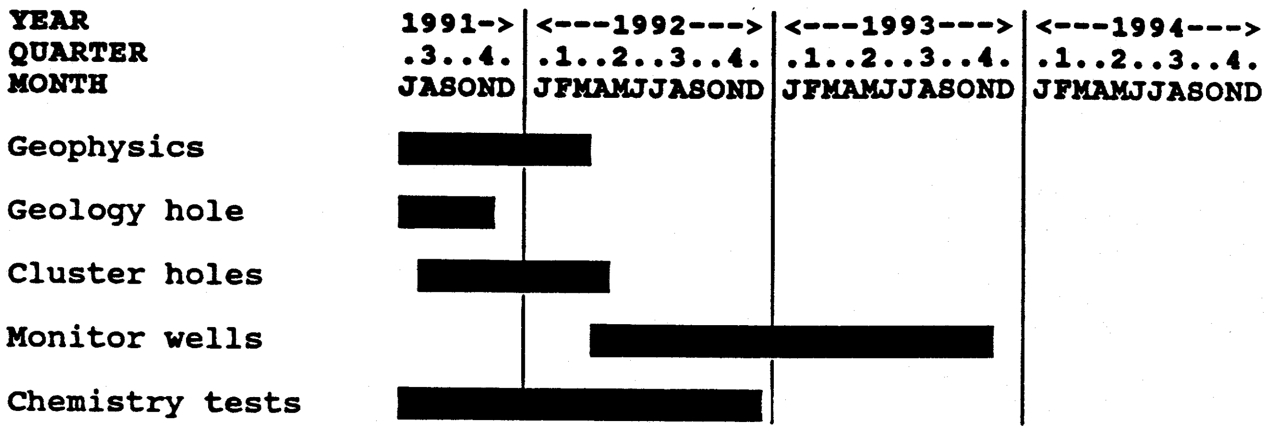
3. Drilling of a single cluster of 4 to 5 wells around the deep well, to provide detailed information on the groundwater and solid phase chemistry of the central plume area. The cluster wells will be sampled for solid phase chemistry, groundwater chemistry, and downhole geophysics continuously between ground surface and potentially 1,500 feet. Results will allow detailed understanding of the behavior of the heart of the plume and calibration of the results of downhole geophysical investigation of the plume by direct measurement of soil and groundwater conditions.

4. Drilling of five monitoring wells to enable water level measurements, water sampling, and plume profiling within and down gradient of the plume, to better define the current and future conditions of the plume, and to assist in the identification of the extent to which the plume is undergoing natural remediation.

5. Performance of geochemical evaluations on saturated zone solids to assess neutralization potential, fixation of metals by adsorption and precipitation, and precipitation of solid phase sulfate.

1.4 WORK SCHEDULE

SCHEDULE - PLUME INVESTIGATION



1.5 DELIVERABLES

The deliverables for the project will be as follows:

1. A report describing the results of the 1991/1992 field program, integrating the information gained with prior information collected and reported, including groundwater quality, soil quality, plume location and depth, and plume movement over time. This report will have an outline similar to that set out in Table 2.

2. A report describing the results of the 1992/1993 field program, integrating the information gained with prior information collected and reported, including groundwater quality, soil quality, plume location and depth, and plume movement over time. This report will have an outline similar to that set out in Table 2.

3. Individual reports for the drilling, chemical testing, and geophysical programs, as noted in Section 2, below.

Table 2. Site Characterization Report Format

Executive Summary

1.0 Introduction
- 1.1 Purpose of Report
- 1.2 Site Background
  - 1.2.1 Site Description
  - 1.2.2 Site History
  - 1.2.3 Previous Investigations
- 1.3 Report Organization

2.0 Study Area Investigation
Field activities associated with site characterization
(could include surface features, contaminant source investigations, surface water and sediment investigations, geological investigations, soil and vadose zone investigations, groundwater investigations)

3.0 Physical Characteristics of the Study Area
Field activities associated with determination of physical characteristics (could include surface features, meteorology, surface-water hydrology, geology, soils, hydrogeology, demography and land use, ecology)

4.0 Nature and Extent of Contamination
Results of site characterization including natural and chemical components and contaminants in (*for example*) sources, soils, vadose zone, groundwater, surface water, air

5.0 Contaminant Fate and Transport
- 5.1 Potential Routes of Migration
- 5.2 Contaminant Persistence
- 5.3 Contaminant Migration

6.0 Summary and Conclusions
- 6.1 Summary
  - 6.1.1 Nature and Extent of Contamination
  - 6.1.2 Fate and Transport
- 6.2 Conclusions
  - 6.2.1 Data Limitations and Recommendations for Future Work
  - 6.2.2 Recommended Remedial Action Objectives

Appendices
- A. Technical Memoranda on Field Activities
- B. Analytical Data and QA/QC Evaluation Results

1.6 REFERENCES

Adrian Brown Consultants, Inc., and Adrian Smith Consulting Inc., 1990, Bingham Creek groundwater remediation program, Salt Lake County, Utah: Contractor Report to Kennecott Corporation, November, 50 p., 5 appendices.

Adrian Brown Consultants, Inc., 1991a, Quality Assurance Project Plan for Kennecott Utah Copper Environmental Actions: Contractor Report to Kennecott Corporation, June, 33 p., 4 appendices.

Adrian Brown Consultants, Inc., 1991b, Health and Safety Plan for Kennecott Utah Copper Environmental Actions: Contractor Report to Kennecott Corporation, June, 14 p., 2 appendices.

Callender, J.F., 1990, Reconnaissance geology of the eastern edge of the Kennecott Utah Copper mine: Contractor Report to Adrian Brown Consultants, Inc., May, 9 p., 2 appendices.

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EPA, 1988, Guidance for conducting remedial investigations and feasibility studies under CERCLA: Interim Final Report, OWSER Directive 9355.3-01, EPA/540/G-89/004, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, October, 120 p., 6 appendices.

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Logsdon, M.L. and Basse, B., 1991, Quantitative evaluation of Pb-Zn mine wastes for subgrade disposal - characterization versus classification in a Superfund environment: Proceedings of the Annual Meeting, AIME, Environmental Management for the 1990's, Denver, Colorado, February, p. 207-212.

Smith, W.H., 1961, The volcanics of the eastern slopes of the Bingham district, Utah, <u>in</u> D.R. Cook, ed., Geology of the Bingham mining district and northern Oquirrh Mountains: Utah Geological and Mineralogical Survey Guidebook to the Geology of Utah 16, p. 101-119.

Smith, W.H., 1975, General structural geology of the Bingham mining district, <u>in</u> R.E. Bray and J.C. Wilson, eds., Guidebook to the Bingham mining district: Tulsa, Oklahoma, Society of Economic Geologists, p. 41-48.

2.0 FIELD SAMPLING PLAN

2.1 DRILLING PROGRAM

2.1.1 Background

The Bingham Channel Groundwater Plume remedial report (ABC/ASCI, 1990) provided a compilation of groundwater data available to date from various drilling programs and the ongoing Bingham groundwater monitoring program. From this evaluation, various remedial alternatives were suggested for the low pH/metals plume. In order to test and further define the various remedial alternatives, a drilling program has been designed to obtain specific information with respect to the geologic framework, hydrology, and solid and water chemistry of the plume area.

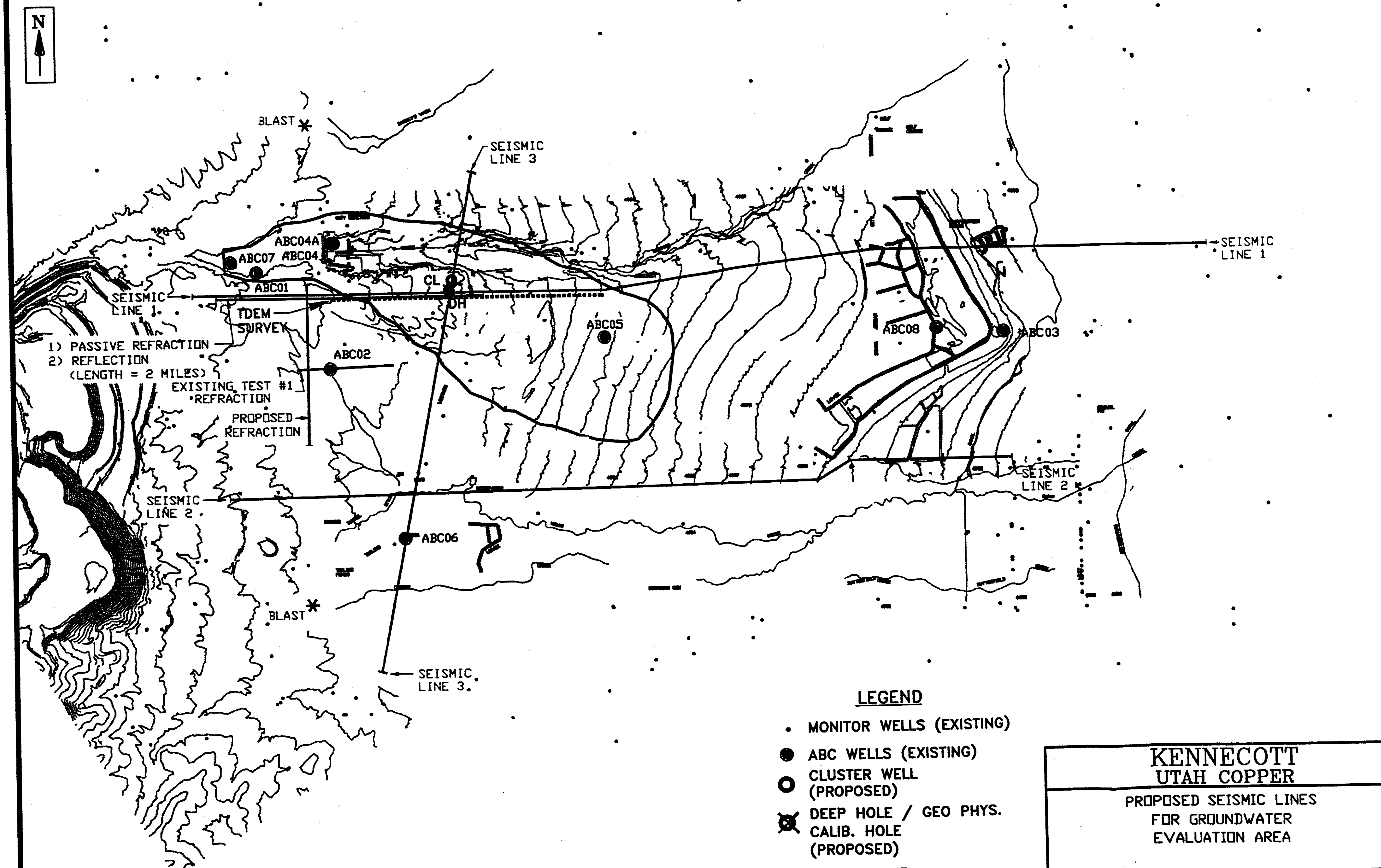
2.1.2 Objectives

The objective of the Bingham Channel Groundwater Plume investigation is to complete the definition of the plume, to determine the extent to which the plume is migrating to the east, and to understand the processes which are controlling migration of the plume. The drilling program has been designed to collect the various types of information necessary to achieve these objectives.

2.1.3 Technical Approach

At least ten holes will be drilled to accomplish the objectives listed above. The drilling program requires that several different methods for drilling, sampling, handling, and analyses be used. These methods are described below and are found in more detail in the Standard Operating Procedures (SOP's) to be included in a Quality Assurance Program Plan.

As described in Section 1 and in more detail below, the wells are grouped according to function. Figure 1 shows the expected location of all drill holes; the drilling and completion methods for each hole are described in detail below.



LEGEND

- MONITOR WELLS (EXISTING)
- ABC WELLS (EXISTING)
- CLUSTER WELL (PROPOSED)
- DEEP HOLE / GEO PHYS. CALIB. HOLE (PROPOSED)
- SEISMIC LINE

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PROPOSED SEISMIC LINES
FOR GROUNDWATER
EVALUATION AREA

Date 6/26/91 | Dwg. No. 451-T-426 | REVISION 3

Deep Geologic/Seismic Calibration Hole: The deep hole, located in the central portion of the plume, is the key to understanding the full hydrostratigraphic section from the surface to the underlying bedrock. It provides the initial definition of the plume at this location, including the geology, the top and bottom of the plume, the base of the groundwater flow system (as defined by low permeability units such as the Jordan Narrows unit), and the location of bedrock. In addition, this hole will provide both geologic and borehole geophysics for calibration of the surface seismic survey.

In order to best achieve these objectives, the deep geologic/seismic calibration hole will be drilled to total depth using standard mud-rotary methods, as described below and shown in Figure 2. The intended total depth of this hole will be defined by the depth to bedrock[1] and drilling an additional 50 to 100 feet for confirmation. Our best estimate to total depth is 2500 feet below ground surface, based on available information. If bedrock is not encountered within 2500 feet of the surface, a deeper target depth may be set. The expected limitation of the drill rig is 4000 feet, which therefore is the lower possible drilling limit. However, since the surface geophysics will have been performed prior to the drilling of this hole, estimates for the depth to bedrock will be available prior to drilling.

The following provides an outline of the procedures for well drilling and completion, and data collection:

Drilling/Completion:

1. After drilling a 19-inch hole to 20 feet, install a 14-inch steel surface casing and cement.
2. Drill a 12-inch hole to approximately 2500 feet by standard mud-rotary.
3. Geophysically log the entire open hole (see list provided below for geophysical tools to be used).
4. Install 4.5-inch diameter (I.D.), fiberglass casing to 2500 feet, with approximately 100 feet of fiberglass well screen.

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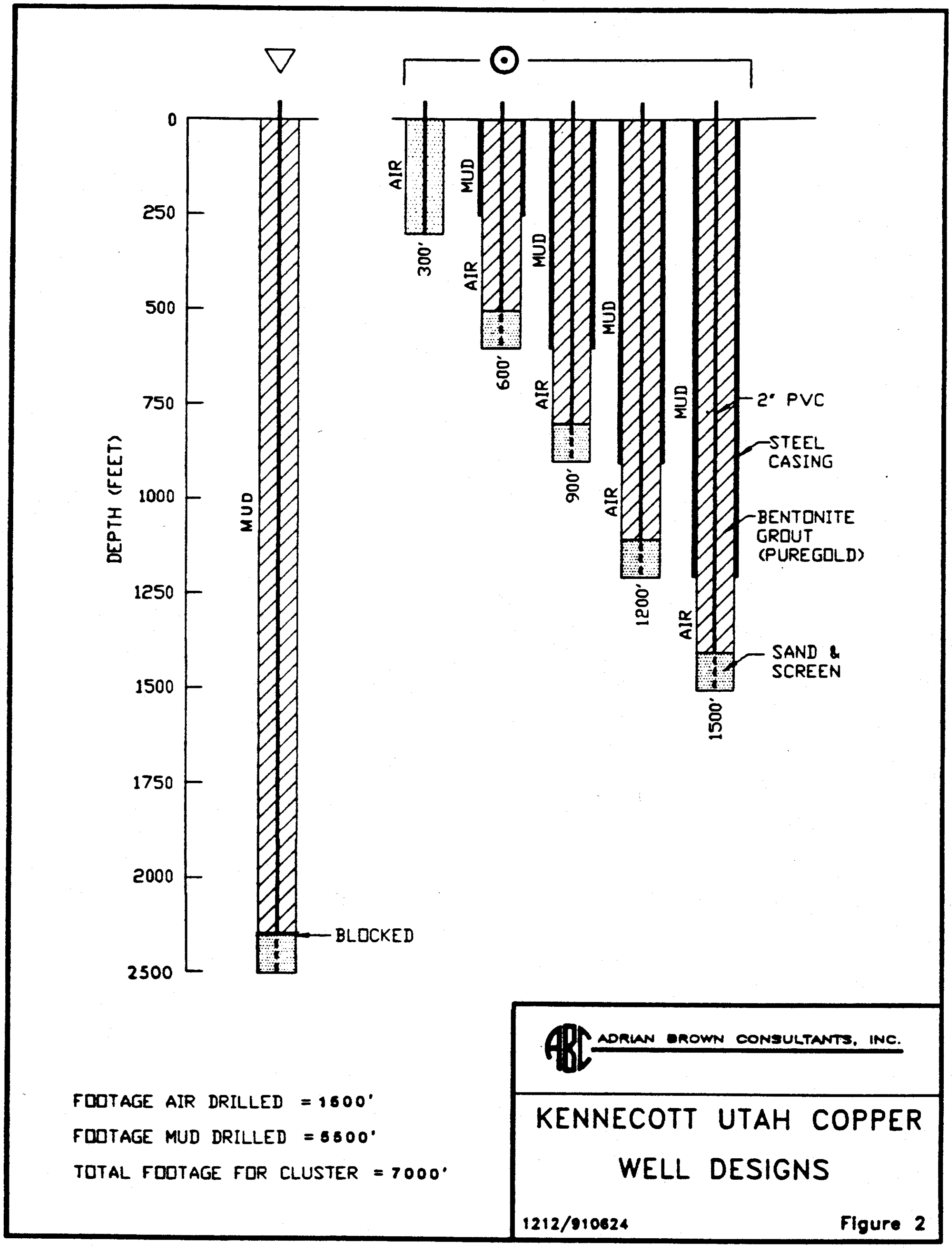
[1] Bedrock, for these purposes, is defined as consolidated material which is continuous for at least 50 feet. It is expected that bedrock at this hole location will be volcanic flows or breccias, however Paleozoic quartzites or limestones are also possible.



KENNECOTT UTAH COPPER

WELL DESIGNS

1212/910624 Figure 2

5. Install approximately 120 feet of silica sand, using a tremmie pipe.
6. Seal annulus with Pure-Gold bentonite to within 30 feet of the surface, using a tremmie pipe.
7. Cement upper 30 feet of hole and install protective casing and locking cap.
8. Develop by air-lifting.
9. After completion, geophysically log through the casing (see list provided below for geophysical tools to be used).

Data will be collected as follows:

1. Drill cuttings will be logged continuously and a bagged sample collected every five feet.
2. The following geophysical tools will be run in an open hole after drilling to total depth: gamma ray, neutron, density, induction, micro-resistivity, spontaneous potential, caliper, temperature, and sonic logger. An additional suite of logs (gamma ray, induction, and neutron) will be run in the completed well after completion of the monitoring well. These logs will provide geologic, hydrologic, and geochemical information with depth such as lithology, porosity, hydraulic conductivity, permeability, and water quality.
3. Since the hole is to be drilled with mud, water samples will only be collected after installation of the monitoring well.
4. A single well permeability test may be conducted at this well dependent on upon the nature of the final completion and the depth to bedrock.

Cluster Holes: A cluster of four to five wells[2] will be located in the central portion of the plume near the deep hole (Figure 1). Drilling and completion of these holes will provide an essentially continuous profile of the current solid and liquid chemistry conditions from the surface to potentially 1500 feet (Figure 2). Drive samples will be collected to provide relatively undisturbed

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[2] Number of wells drilled will be based on information collected during the deep (2500 ft) hole. The 1500 ft well may not be necessary, if the 1200 ft well provides adequate coverage below the plume and also provides sufficient information regarding the Jordan Narrows unit.

samples to assess the physical characteristics of the alluvial fan. The holes will also be used to assess the capabilities of the geophysical logging methods in understanding plume conditions. These holes will then be completed as monitoring wells at different depths to evaluate vertical gradients and changing plume conditions over time.

In order to best achieve these objectives, a combination of reverse-air and mud-rotary drilling techniques will be used. Previous drilling experience in the alluvial fan materials has shown a subsurface reverse-air drilling limitation of about 300 feet in the unconsolidated material near Kennecott. Beyond this length of open hole, caving and sloughing require the installation of casing in order to continue reverse-air drilling. Hence, a series of holes (a cluster) are to be drilled, each providing a reverse-air-drilled interval of approximately 300 feet, which in composite will cover the full 1200 to 1500 feet drilled. Alternate drilling strategies were considered for this program, but based on the previous experience, this strategy proved to be the most cost-effective, as well as providing groundwater monitoring from multiple zones.

The discussion below provides the detailed drilling and well completion procedures for the proposed five cluster wells, as well as a description of the data to be collected.

<u>1500 foot Cluster Hole</u>

Drilling/Completion:

1. Drill a 25-inch hole to 20 feet and install 20 feet of 20-inch steel surface casing and cement.
2. Drill a 19-inch hole to 1200 feet by standard mud-rotary methods.
3. Geophysically log the open hole (see list provided below for geophysical tools to be used).
4. Install 14-inch diameter steel casing to 1200 feet and cement.
5. Drill to 1500 feet using reverse-air and a 5 1/2-inch bit.
6. After mudding hole, geophysically log bottom 300 feet (see list provided below for geophysical tools to be used).
7. Ream hole to 12-inches.
8. Install 1500 feet of 4.5-inch fiberglass casing, the bottom 40 feet of which is to be screened.
9. Using a tremmie pipe, install approximately 50 feet of silica sand.

10. Install Pure-Gold grout to within 30 feet of surface, using a tremmie pipe.
11. Cement upper 30 feet of hole and install protective casing and locking cap.
12. Develop by air-lifting.
13. After completion, geophysically log through the casing (see list provided below for geophysical tools to be used).

Data will be collected as follows:

1. Drill cuttings will be logged continuously.
2. Drill cutting samples will be collected every five feet.
3. Formation fluid field parameters (e.g., pH, conductivity) will be measured every five feet during reverse-air drilling.
4. Water samples will be collected in the reverse-air drilled portion of each hole every 20 feet and a water sample will be collected after completion of the monitoring well.
5. Drive samples will be taken every 50 feet in the reverse-air drilled portion of each hole.
6. All or some of the following geophysical tools will be run in an open hole after drilling to total depth: gamma ray, neutron, density, induction, micro-resistivity, spontaneous potential, caliper, and temperature. An additional suite of logs (gamma ray, induction, and neutron) will be collected after completion of the monitoring well. These logs will provide geologic, hydrologic, and geochemical information with depth such as lithology, porosity, hydraulic conductivity, permeability, and water quality.
7. Sieve analysis will be conducted on each drive sample.
8. A single well permeability test will be conducted in the completed well.

<u>1200 foot Cluster Hole</u>

Drilling/Completion:

1. Drill a 25-inch hole to 20 feet and install 20 feet of 20-inch steel surface casing and cement.
2. Drill a 19-inch hole to 900 feet by standard mud-rotary methods.
3. Geophysically log the open hole (see list provided below for geophysical tools to be used).

4. Install 14-inch diameter steel casing to 900 feet and cement.
5. Drill to 1200 feet using reverse-air and a 5 1/2-inch bit.
6. After mudding hole, geophysically log bottom 300 feet (see list provided below for geophysical tools to be used).
7. Ream hole to 12-inches.
8. Install 1200 feet of 4.5-inch fiberglass casing, the bottom 40 feet of which is to be screened.
9. Using a tremmie pipe, install approximately 50 feet of silica sand.
10. Install Pure-Gold grout to within 30 feet of surface, using a tremmie pipe.
11. Cement upper 30 feet of hole and install protective casing and locking cap.
12. Develop by air-lifting.
13. After completion, geophysically log through the casing (see list provided below for geophysical tools to be used).

Data will be collected as follows:

1. Drill cuttings will be logged continuously.
2. Drill cutting samples will be collected every five feet.
3. Formation fluid field parameters (e.g., pH, conductivity) will be measured every five feet during reverse-air drilling.
4. Water samples will be collected in the reverse-air drilled portion of each hole every 20 feet and a water sample will be collected after completion of the monitoring well.
5. Drive samples will be taken every 50 feet in the reverse-air drilled portion of each hole.
6. All or some of the following geophysical tools will be run in an open hole after drilling to total depth: gamma ray, neutron, density, induction, micro-resistivity, spontaneous potential, caliper, and temperature. An additional suite of logs (gamma ray, induction, and neutron) will be collected after completion of the monitoring well. These logs will provide geologic, hydrologic, and geochemical information with depth such as lithology, porosity, hydraulic conductivity, permeability, and water quality.
7. Sieve analysis will be conducted on each drive sample.
8. A single well permeability test will be conducted in the completed well.

900 foot Cluster Hole

Drilling/Completion:

1. Drill a 25-inch hole to 20 feet and install 20 feet of 20-inch steel surface casing and cement.
2. Drill a 19-inch hole to 600 feet by standard mud-rotary methods.
3. Geophysically log the open hole (see list provided below for geophysical tools to be used).
4. Install 14-inch diameter steel casing to 600 feet and cement.
5. Drill to 900 feet using reverse-air and a 5 1/2-inch bit.
6. After mudding hole, geophysically log bottom 300 feet (see list provided below for geophysical tools to be used).
7. Ream hole to 12-inches.
8. Install 900 feet of 4.5-inch fiberglass casing, the bottom 40 feet of which is to be screened.
9. Using a tremmie pipe, install approximately 50 feet of silica sand.
10. Install Pure-Gold grout to within 30 feet of surface, using a tremmie pipe.
11. Cement upper 30 feet of hole and install protective casing and locking cap.
12. Develop by air-lifting.
13. After completion, geophysically log through the casing (see list provided below for geophysical tools to be used).

Data will be collected as follows:

1. Drill cuttings will be logged continuously.
2. Drill cutting samples will be collected every five feet.
3. Formation fluid field parameters (e.g., pH, conductivity) will be measured every five feet during reverse-air drilling.
4. Water samples will be collected in the reverse-air drilled portion of each hole every 20 feet and a water sample will be collected after completion of the monitoring well.
5. Drive samples will be taken every 50 feet in the reverse-air drilled portion of each hole.
6. All or some of the following geophysical tools will be run in an open hole after drilling to total depth: gamma ray, neutron, density, induction, micro-resistivity, spontaneous potential, caliper, and temperature. An additional suite of logs (gamma ray, induction, and

neutron) will be collected after completion of the monitoring well. These logs will provide geologic, hydrologic, and geochemical information with depth such as lithology, porosity, hydraulic conductivity, permeability, and water quality.

7. Sieve analysis will be conducted on each drive sample.
8. A single well permeability test will be conducted in the completed well.

<u>600 foot Cluster Hole</u>

Drilling/Completion:

1. Drill a 25-inch hole to 20 feet and install 20 feet of 20-inch steel surface casing and cement.
2. Drill a 19-inch hole to 300 feet by standard mud-rotary methods.
3. Geophysically log the open hole (see list provided below for geophysical tools to be used).
4. Install 14-inch diameter steel casing to 300 feet and cement.
5. Drill to 600 feet using reverse-air and a 5 1/2-inch bit.
6. After mudding hole, geophysically log bottom 300 feet (see list provided below for geophysical tools to be used).
7. Ream hole to 12-inches.
8. Install 600 feet of 4.5-inch fiberglass casing, the bottom 40 feet of which is to be screened.
9. Using a tremmie pipe, install approximately 50 feet of silica sand.
10. Install Pure-Gold grout to within 30 feet of surface, using a tremmie pipe.
11. Cement upper 30 feet of hole and install protective casing and locking cap.
12. Develop by air-lifting.
13. After completion, geophysically log through the casing (see list provided below for geophysical tools to be used).

Data will be collected as follows:

1. Drill cuttings will be logged continuously.
2. Drill cutting samples will be collected every five feet.
3. Formation fluid field parameters (e.g., pH, conductivity) will be measured every five feet during reverse-air drilling.

4. Water samples will be collected in the reverse-air drilled portion of each hole every 20 feet and a water sample will be collected after completion of the monitoring well.
5. Drive samples will be taken every 50 feet in the reverse-air drilled portion of each hole.
6. All or some of the following geophysical tools will be run in an open hole after drilling to total depth: gamma ray, neutron, density, induction, micro-resistivity, spontaneous potential, caliper, and temperature. An additional suite of logs (gamma ray, induction, and neutron) will be collected after completion of the monitoring well. These logs will provide geologic, hydrologic, and geochemical information with depth such as lithology, porosity, hydraulic conductivity, permeability, and water quality.
7. Sieve analysis will be conducted on each drive sample.
8. A single well permeability test will be conducted in the completed well.

300 foot Cluster Hole

Drilling/Completion:

1. Drill a six-inch hole to the top of the water table (~300 feet) using reverse-air (no fluids are to be used in drilling or completing this hole). Drill at least 40 feet below the top of the water table.
2. Install 300 feet of 2-inch PVC, schedule 80 pipe, with the bottom 40 feet being screen.
3. Using a tremmie pipe, install silica sand to within five feet of the surface.
4. Cement upper 5 feet of hole and install protective casing and locking cap.
5. After completion, geophysically log through the casing (see list provided below for geophysical tools to be used).

Data will be collected as follows:

1. Drill cuttings will be logged continuously.
2. Drill cutting samples will be collected every five feet.
3. Water samples will be collected at the top of the water table and every 20 feet thereafter.
4. All or some of the following geophysical tools will be run in the cased hole after completion of the monitoring well:

gamma ray, neutron, induction. These logs will provide geologic, hydrologic, and geochemical information with depth such as lithology, porosity, hydraulic conductivity, permeability, and water quality.

Based on available information, no major decisions will be required regarding the geology and termination of drilling of the seven cluster wells. However, depending upon the results of the deep geologic/seismic calibration hole, the design of the cluster wells could be modified. For example, additional information on the depth to the Jordan Narrows unit might suggest a modification to the intended depths of monitoring in the cluster system. The thickness of the vadose zone, and therefore the depth of the hole will be defined on the basis of the actual water levels measured in previously drilled cluster wells.

Paired Wells: Several additional monitoring wells are planned to more fully define the vertical and horizontal extent of the plume, vertical gradients and changes in the plume over time. The wells are also designed to monitor the plume's response to natural remediation processes and the source control program. The wells will consist of a deep hole which will be drilled through the plume and completed at approximately 1200 feet, based on presently available information, and a few (~4) shallow holes which will be drilled to approximately 600 feet and be completed within the heart of the plume. The deep hole will provide access for geophysical logging in an attempt to monitor changes in the plume geometry and chemistry. The shallow hole at each location will provide direct access to the plume (via the completed interval) for calibration of the geophysical results. Possible locations of these well pairs are shown in Figure 2.

In order to best achieve these objectives, each hole will be drilled by mud-rotary. The detailed drilling and completion procedures are outlined below:

<u>Monitoring Wells - Shallow</u>

Drilling/Completion:

1. Install 20 feet of surface casing, if deemed necessary by the drill crew.
2. Drill 7-inch hole with mud-rotary to approximately 600 feet. This depth will vary depending upon depth and thickness of the plume at each location.

3. Log hole geophysically (see list provided below for geophysical tools to be used).
4. Install 600 feet of 4.5-inch fiberglass casing, the bottom 100 feet of which is screened.
5. Using tremmie pipe, install approximately 130 feet of silica sand.
6. Install Pure-Gold grout to within 30 feet of surface, using a tremmie pipe.
7. Cement upper 30 feet and install protective casing and locking cap.
8. Develop with air.
9. After completion, geophysically log hole from inside casing (see list provided below for geophysical tools to be used).

Specific data will be collected as follows:

1. Drill cuttings will be logged continuously.
2. Drill cutting samples will be collected every five feet.
3. Water samples will be collected after completion of the monitoring well.
4. All or some of the following geophysical tools will be run in the open hole after drilling to total depth: gamma ray, neutron, density, induction, micro-resistivity, spontaneous potential, caliper, and temperature. Gamma ray and induction logs will be run in the cased hole after completion of the monitoring well. These logs will provide geologic, hydrologic, and geochemical information with depth such as lithology, porosity, hydraulic conductivity, permeability, and water quality.
5. A single well permeability test may be conducted at this well dependent on how the hole is finally drilled and the need for additional permeability data.

Monitoring Well - Deep

Drilling/Completion:

1. Drill a 12-inch hole to 20 feet and install a 20-inch steel surface casing and cement.
2. Drill 7-inch hole with mud-rotary to approximately 1200 feet. This depth will vary depending upon depth and thickness of the plume at each location.
3. Geophysically log the open hole (see list provided below for geophysical tools to be used).

4. Install 1200 feet of 4.5-inch fiberglass casing, the bottom 40 feet of which is screened.
5. Using tremmie pipe, install approximately 50 feet of silica sand.
6. Install Pure-Gold grout to within 30 feet of surface, using a tremmie pipe.
7. Cement upper 30 feet and install protective casing and locking cap.
8. Develop with air.
9. After completion, geophysically log hole from inside casing (see list provided below for geophysical tools to be used).

Specific data will be collected as follows:

1. Drill cuttings will be logged continuously.
2. Drill cutting samples will be collected every five feet.
3. Water samples will be collected after completion of the monitoring well.
4. All or some of the following geophysical tools will be run in the open hole after drilling to total depth: gamma ray, neutron, density, induction, micro-resistivity, spontaneous potential, caliper, and temperature. Gamma ray and induction logs will be run in the cased hole after completion of the monitoring well. These logs will provide geologic, hydrologic, and geochemical information with depth such as lithology, porosity, hydraulic conductivity, permeability, and water quality.
5. A single well permeability test may be conducted at this well dependent on how the hole is finally drilled and the need for additional permeability data.

Assuming the borehole logging proves effective, the necessity of the solids chemistry data will be evaluated for each proposed well location, on a data-needs basis. If the solids chemistry data of interest is necessary, some portion of the hole(s) will be drilled using reverse-air.

The initial estimated depth of each monitoring well will be established prior to drilling by reviewing all nearby well data to determine as accurately as possible the thickness of the plume in the vicinity of the paired wells. Final determination will be made in the field based on the results of the field measurements.

2.1.4 Drilling Methods

There are two basic drilling styles which will be employed in this program: conventional mud-rotary and reverse-air. The drilling method to be used in each hole or portion of hole will be determined by the type of soil and water sample required at each location or depth. The mud-rotary method will be used where the primary objective is to provide a hole for geophysical logging and stratigraphic determinations. Reverse-air will be used where relatively unaffected solid samples are required, as well as providing water chemistry data through a given interval.

Mud-rotary drilling will be performed with standard single-walled drill pipe and conventional bit. Conventional bentonite-based drilling mud will be used.

Reverse-air drilling will be performed with double-walled drill pipe and the appropriate bit. Fluids (water) will not be used with this drilling method, except when necessary due to poor returns, which usually occurs near the water table. Once sufficient formation water is produced, injection of water is not necessary.

2.1.5 Sampling Methods

2.1.5.1 Sample location and frequency

The following sample types will be collected during the course of the drilling investigation:

1. Drill cuttings - mud-rotary
2. Drill cuttings - reverse-air
3. Drive samples
4. Formation water - field parameters (during reverse-air drilling)
5. Formation water - chemical analysis (during reverse-air drilling)
6. Formation water - at the end of well development

The specific location and frequency for the collection of the various samples are discussed above.

2.1.5.2 Sample designation

All samples collected from the various drill holes will be numbered in a manner consistent with previous drilling. Samples will be identified by the hole number, the depth, W for water samples, and the sample date. Solid sample numbers will appear the same, except will not include the letter W.

2.1.5.3 Sampling equipment and procedures

Each sample type will require specific equipment and procedures, which will be outlined in SOP's to be included in a Quality Assurance Program Plan. The following provides a list of SOP's which specifically deal with collection of the various sample types:

1. SOP-100: Collection and handling of drill cuttings: Mud-rotary
2. SOP-101: Collection and handling of drill cuttings: Reverse-air
3. SOP-102: Collection and handling of drive samples
4. SOP-103: Collection of groundwater samples for analysis
5. SOP-104: Preparation of water samples
6. SOP-105: Solid sample splitting.

2.1.5.4 Sample handing and analysis

Sample handling for each of the anticipated sample types is discussed in the SOP's listed above. Sample handling will include bagging, transportation, splitting, routing, and storage. The analyses to be performed as part of the groundwater plume study are summarized in Table 3.

Table 3. Chemical Parameters for Groundwater Plume Analyses

PARAMETER	GROUNDWATER	SOLIDS
Acidity/Alkalinity	T	NA
Available Neutralization Potential	NA	T
pH	T	Paste
Specific Conductance	T	Paste
TDS	T	NA
Ca	T	TD; L
Mg	T	TD;L
Na	T	TD; L
K	T	TD; L
HCO3/CO3	T	NA
Cl	T	NA
SO_4	T	TD; L
B	T	Na
Li	T	TD
Sr	T	TD
F	T	NA
$NO_3 + NO_2$	T	NA
As	D	TD
Ba	D	TD
Cd	D	TD
Cr (Total)	D	TD
Co	D	TD
Cu	D	TD
Fe	D	TD
Pb	D	TD

PARAMETER	GROUNDWATER	SOLIDS
Mn	D	TD
Se	D	TD
Ag	D	TD
Zn	D	TD
Gross Alpha	D	NA
Gross Beta	D	NA
Ra-226+228	D	NA
U	D	NA

1. D: Dissolved
   T: Total
   TD: Total Digestible
   L: Leachable
   NA: Not Applicable to this phase

2. Analyses will be performed using the procedures of USEPA, 1986, Test methods for Evaluating Solid Waste, Physical/Chemical Methods: SW-846, third edition, except as follows:

   The following tests will be performed using the test procedures developed by KEL/ABC in 1990:

   - o Available Neutralization Potential

   - o Leachable Sulfate and Leachable Cations

   These test methods are presented in ABC, 1990, Laboratory Test Results... In addition, the test procedures are on file with KEL, where they are available for review on reasonable notice.

3. Minimum detection limits will be those of the EPA Contract Laboratory Program Routine Analytical Services, except that the detection limit for ANP will be 10 mg $CaCO_3$ equivalent per kg solid, and the detection limit for Leachable Species will be 10 mg/kg.

2.1.5.5 Sample Paperwork

Traffic reports. Traffic reports will not be used in this project. Chain of custody forms will be used to track the progress of the various samples.

Chain of custody form. A chain of custody form will be used in all circumstances.

SAS packing list. SAS packing list does not apply to this program.

Sample tags. Sample tags consistent with the previous drilling program will be used. The specific labeling procedures are outlined in SOP-104 (Sample labeling).

2.1.6 Deliverables

A well report will be produced for each well drilled, and will include the following:

- Purpose of the well
- Description of the drilling and completion activities
- Geologic description and pictorial log of the hole
- Geophysical logs of the hole (if any)
- Description of the sampling performed
- Results of sampling/testing at the well site
- Results of laboratory testing (when available)
- Results of any hydraulic testing

2.2 LARGE-SCALE DYNAMIC CHEMICAL TESTING PROGRAM

2.2.1 Background

The Bingham Channel Groundwater Plume remedial report (ABC/ASCI, 1990) identified a set of physico-chemical processes that lead to the natural, in-situ control of plume migration. These processes include:

- Neutralization of the acidity of the contaminated groundwater;
- Precipitation and absorption of metals;
- Ion exchange of magnesium and calcium;
- Precipitation of solid-phase sulfate (presumably as gypsum);
- Dilution.

The success of any remedial approach depends on the chemistry, including kinetics, of the reaction between the low-pH/high-metals/high-magnesium/high-sulfate fluid and the host sediments. Laboratory studies have indicated that the chemistry of the solid and fluid phases is compatible with in-situ cleanup, but the large-scale behavior and the kinetics of the reactions have not been demonstrated.

2.2.2 Objective

The objective of this testing is to examine the chemical mechanisms controlling contaminant migration including neutralization, precipitation, and ion-exchange. This testing approach is controllable, realistic in terms of physical and temporal scale, and directly observable (e.g., Logsdon and Basse, 1991).

2.2.3 Technical Approach

The testing program has three major components:

- One large-scale (approximately 500 ft^3) tank test of the reaction of acid-sulfate water with natural alluvium unaffected by reactions with the groundwater plume. The test will operate for one year.

- One large-scale (approximately 500 ft^3) tank test of the reaction of natural groundwater with acid- and sulfate-affected alluvium. The test will operate for one year.

- A series of up to 20 column tests that will be performed in parallel with the tank tests to assess quality control and the effects of parametric variations in experimental design that cannot be accommodated in the large-scale tank tests. Column tests are expected to continue throughout the one-year time frame, but individual tests may range in duration from a few weeks to the full year.

The large reaction vessels will be cylindrical tanks that are eight feet in diameter and 10 to 12 feet high (Figures 3 and 4). The tanks will be fabricated from 3/8-inch mild steel and wrapped in fiberglass insulation to approximate adiabatic conditions during the tests. The tanks will be painted inside and out with a non-reactive enamel type paint to prevent reaction of the acidic water with the steel. The flow-through columns will be constructed of 8-inch PVC in lengths from 3 feet to 10 feet. The tanks and columns will be installed in a secure warehouse.

Samples of both the fluid and the solid phases will be collected for chemical analyses using standard sampling protocols and standard analytical methods for chemical analyses.

2.2.4 Scope of Work

2.2.4.1 Preliminary Activities

Several preliminary components of the test procedures will be common to all of the tests:

- Preparation of detailed work plans for specific experimental procedures, to include QA/QC and Health and Safety plans to the extent that the material appended to this overall Work Plan needs additional detail.

- Collection and characterization of approximately 100 yd^3 of both natural and acid- and sulfate-affected alluvial fan materials.

Figure 3. Vat Test Tank Design - Plan View

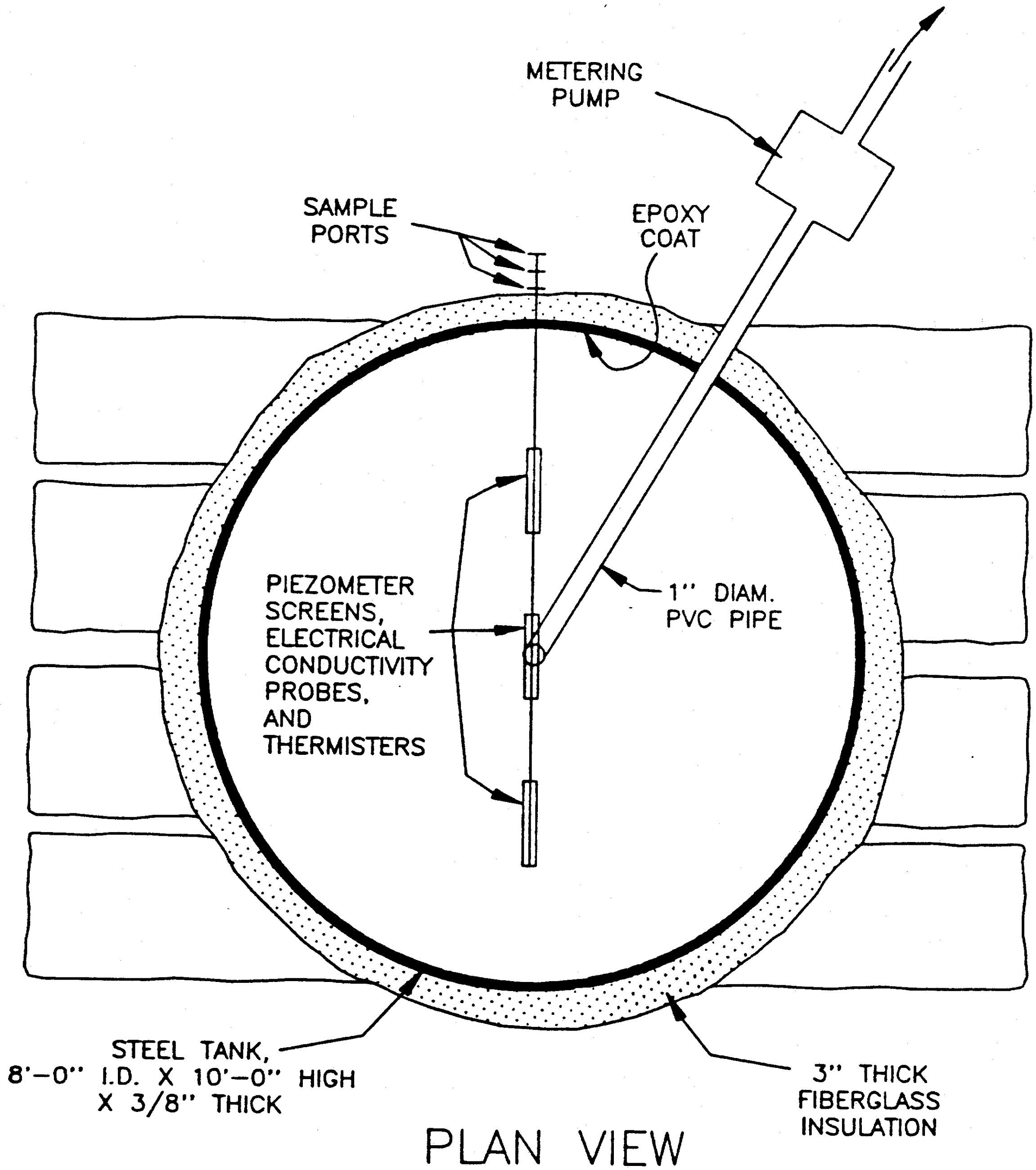
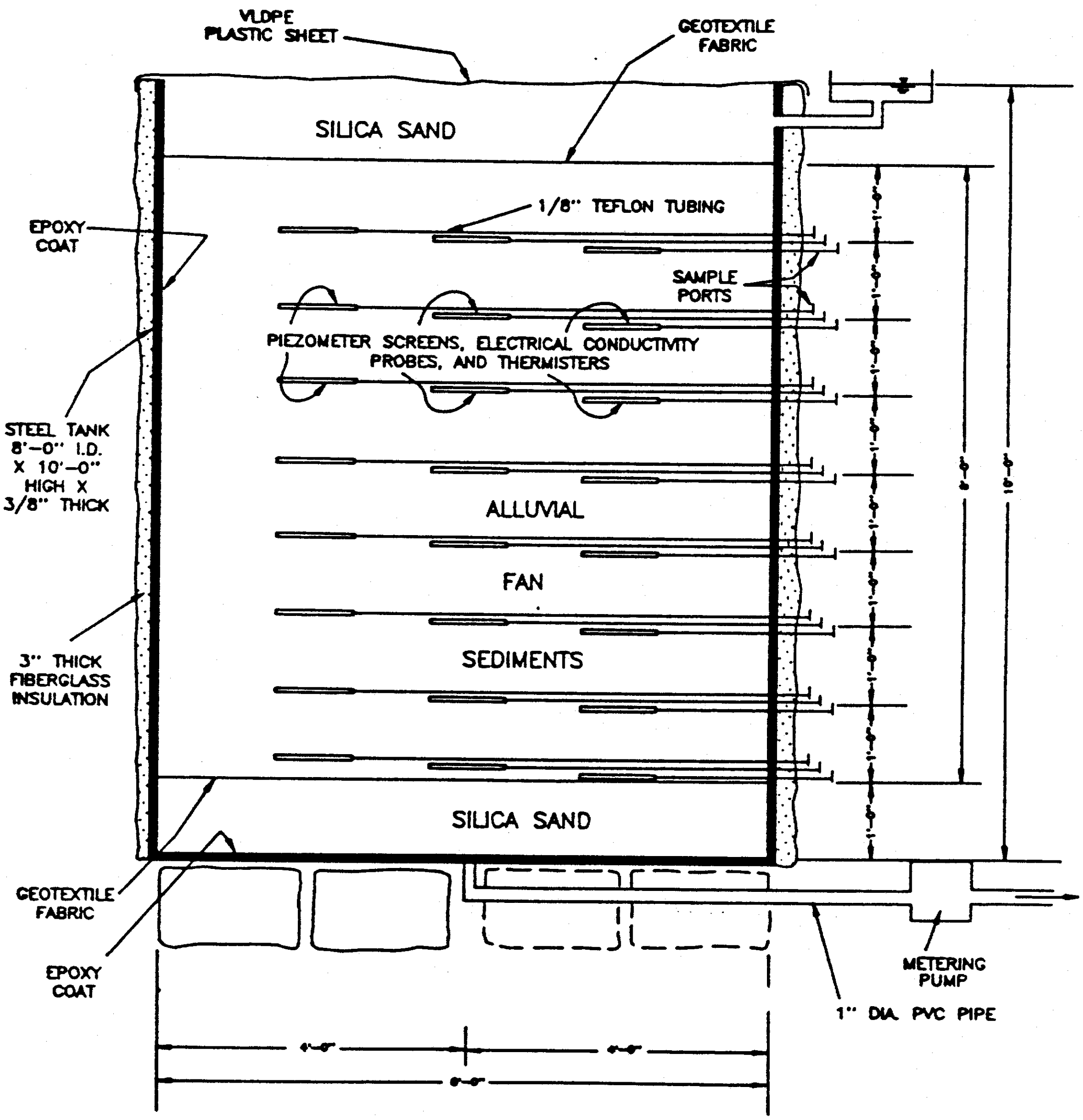


Figure 4. Vat Test Tank Design - Side View



SIDE VIEW

- Outfitting of water sources for both natural groundwater and low-pH/high-metals/high-magnesium, high-sulfate water. The water sources need to be characterized in terms of general chemical and physical parameters, major ions, minor ions, trace metals, and selected radiological species.

  Prior to initiation of testing, testers will collect ten splits of water from each of the two sources for laboratory analysis. The samples will be collected using standard procedures and will be tested at Kennecott Environmental Laboratory to assure comparability with testing results from the 1990 field program.

  Prior to initiation of the large-scale tests, water from these sources will be characterized with respect to the following parameters:

  - General: pH, Eh, dissolved oxygen, specific conductance, TDS, Alkalinity, Acidity, temperature. Temperature, pH, conductivity, and dissolved oxygen will be measured in the field as well as in the laboratory (except temperature).

  - Major ions: Ca, Mg, Na, K, HCO_3/CO_3, SO_4, Cl

  - Minor ions: Sr, Li, B, F, NO_3, NH_3

  - Metals (Total and Dissolved): Al, As, Ba, Cd, Cr, Cu, Fe, Pb, Mn, Mo, Se, Ag, Zn

  - Radiological Species: Gross alpha, Gross beta, Ra-226+228, U

  Ten (10) replicates of each water supply will be tested on the first sampling event, and the water supplies will be sampled in duplicate at the wellhead monthly throughout the test.

- Specific procedures for loading and initial testing of the tanks are as follows:

  a. All ports and plumbing points will be closed and temporarily sealed.

  b. The tank will be filled with system water to test for leaks. A sample of the initial system water will be collected for chemical analysis. The tank will remain filled for 24 hours, at which point a sample of water from the outflow will be collected for analysis to confirm that there has been no reaction with the tank materials. After conclusion of this step, the tank will be emptied.

c. The lower silica sand filter layer will be laid and compacted by hand.

d. The clean alluvial sediments will be laid in 1-ft lifts and compacted to 90% Standard Proctor after adding sufficient moisture to reach ±5% of optimum moisture conditions. Compaction will be tested using standard ASTM methods. At appropriate points, the piezometers and related sampling devices will be installed, and the sediments carefully hand compacted around them to preserve their physical integrity (Figure 3).

e. After 8 feet of alluvial material has been placed and compacted, the top of the test charge will be covered with geotextile fabric and another one foot of silica sand will be placed and gently compacted to provide a distribution medium that will allow flow of the test water to be evenly distributed across the top of the material.

f. After all of the solid material has been placed, compacted and tested, the tank will be flooded with natural groundwater. The water will be introduced under pressure at the bottom of the tank, causing the tank to become saturated from the bottom upward to expel air (to the extent practicable) and fully and evenly saturate the tests charge. The flow rate will be maintained at approximately 0.1 to 0-2 gpm to assure that the saturation is gradual and that no preferential pathways are developed that would compromise later flow conditions.

g. The saturation process will continue until there is one foot of freeboard above the top of the silica sand. At this point, water will be added to bring the water level to within about 3 inches of the top of the tank. Finally, the water will be covered with a blanket of Very Low Density Polyethylene (VLDPE) to prevent evaporation, provide some insulation, and prevent inadvertent introduction of foreign substances.

h. The plumbing will be connected to allow vertical flow downward during the actual experiments and tested.

i. When all of the plumbing is shown to function as designed (i.e., the float-valve system to control flow to the top of the tank and the metering pump that will control flow out of the bottom of the tank), the water quality will be sampled at the outflow valve for the full baseline suite.

j. The tank will remain closed in a static condition for 48 hours to allow the initial water to come into equilibrium with the test charge sediments. Field parameters will be measured at all the internal sampling points at the following time intervals:

- time = 0, 1 hr, 3 hr, 6 hr, 12 hr, 18 hr, 24 hr, 36 hr, 48 hr, and at subsequent 24 hour intervals until steady values of field parameters are achieved.

When steady chemical parameters are reached, a sample of outflow water will be collected and analyzed for the full range of baseline parameters.

The subsequent large-scale tests will occur in the secure warehouse. The principal reason for housing the experiments in a building is to allow control on temperature and to allow working conditions to be sufficiently comfortable year around that reliable measurements can be made. In addition, the building will provide security for the experiments, which may be important in assuring that the results are defensible.

2.2.4.2 Large-Scale Test 1: Acid-Sulfate Water Reacted with Natural Alluvium

The first tank test will assess the chemistry of flowing contaminated water through natural alluvial fan material. Figure 3 is a schematic diagram of the testing apparatus. The first test will proceed as follows:

1. The reaction vessel will be charged with solids using the procedures of Section 2.2.4.1. For this test, the vessel will be charged with material from the characterized stockpile of <u>unaffected</u> (natural) alluvial fan material. Piezometers and related in-situ measuring devices will be installed at various depths and locations in the reaction vessel as it is filled

(see Figure 4). The lift-by-lift and total mass and volume of the solids will be measured.

2. The tank will be flooded with natural groundwater, displacing all air. The water inflow will be carefully metered to allow calculation of the volume and mass of water needed to saturate the system.

   From the volumes of solids and water, the tester will calculate the porosity of the charged material in the test tank.

   Sampling for evaluation of the static portion of the test will follow standard procedures. At the end of the static phase, the experimental team will adjust the valving system to produce an even flow of approximately 0.1 gallons per minute downward through the entire tank. (The volumetric flow rate of 0.1 gpm corresponds to a vertical displacement of a water with density 1.0 traveling at 500 feet/year through a 25 ft^2 (8-ft radius) cross section with a porosity of 0.3. The actual flow rate will be determined after we have made detailed calculations of fluid properties and porosity of the fully charged, compacted, and saturated reaction vessel.)

4. Water will be withdrawn from the bottom of the tank at the determined flow rate (near 0.1 gpm). As flow occurs, water will be added from the header tank holding the reservoir of low-pH/high-metals/high-Mg, high-SO_4 water. Because of the constant head condition above the upper sand filter (created by the float valve on the header tank), the flow through the tank will be controlled by the flow out of the system at the bottom of the tank.

5. Water samples will be taken at up to 24 points in the test tank (via the piezometers that were installed during the charge - see Figure 3), from the outflow sump, and from the header tank (or its distribution system before reaching the reactor). The sampling interval is expected to be approximately as follows:

   Initiation; 1 day, 2 days, 4 days, 8 days, 12 days, 16 days (1 Pore Volume), 24 days, 32 days (2 Pore Volumes days, 48 days (3 Pore Volumes), 64 days (4 Pore Volumes); 80 days (6 Pore Volumes); 112 days (8 Pore Volumes); 160 days (10 Pore Volumes); 320 days (20 pore volumes).

This sampling schedule may be modified on the basis of initial testing of the tank and possible adjustments in flow rates.

The samples will be tested in the field for pH, conductivity, temperature, and dissolved oxygen. Twenty-five percent of the samples will be sent to the laboratory for analysis of pH, Eh, conductivity, TDS, Alkalinity, Acidity, Ca, Mg, SO_4, Cu, Fe, Mn, and Zn. Ten percent of the samples will be analyzed in the laboratory for the full baseline suite of parameters. Approximately 10% additional sampling will be performed for QA/QC.

The test trial will continue until output concentrations for key parameters closely approach the input values, or until 20 pore volumes have been passed through the system (approximately 320 days, or about 10 months).

6. At the conclusion of the test, the tank will be drained, and approximately 15 soil samples will be collected (during excavation for final disposal of solids) at different locations and depths in the reaction tank for analysis of the solid-phase characteristics that were measured prior to testing: grain size, bulk density, slurry pH and specific conductance, Available Neutralization Potential (ANP), Leachable Sulfate (LSO_4) (as well as total sulfate), leachable major cations, Na^+ - Mg^{2+} cation-exchange capacity, and total digestible metals. Three samples (20%) will be collected in duplicate for QA/QC purposes.

2.2.4.3 Large-Scale Test 2: Natural Groundwater Reacted With Acid- and Sulfate-Affected Alluvium

The second large-scale test would be identical to the first, except that:

1. The soil material in the charge will be alluvial fan sediments that have been affected by the leachate from the main Bingham Reservoir.

2. The test charge, after compaction and laying of the upper distribution medium, will be saturated with the low-pH/high-metals, high-Mg, High-SO_4 water.

3. The lixiviant will be natural groundwater.

2.2.4.4 Flow-Through Column Tests

A series of flow-through column tests using the 8"-PVC columns will be performed to develop quality control data and to test selected parametric variations that cannot be evaluated efficiently in the large-scale tests. Detailed procedures and protocols for the column tests will be developed in supplementary work plans. Initial planning for tests includes the following 14 column tests:

1. Parallel with each of the two large-scale tests, we will set up three column tests that are designed to replicate the tanks. (The volumetric flow rates will be scaled to the columns to replicate the design-basis vertical flow of 500 feet/yr.) The purpose of these columns is to collect replicate water quality samples that can be used to document quality control on the chemical analyses in a controlled flow-through environment.

2. For each tank test, we will prepare at least two columns that have layered permeabilities, to test the effects (if any) on chemistry and flow from significant anisotropy in vertical permeability.

3. For each tank test, we will prepare at least two columns with flow rates significantly different from those of the test tanks, to assess the effects of flow rate on the chemistry.

4. At this time, we consider it prudent to reserve three additional columns for each tank test, to allow us to test additional hypotheses and combinations of test parameters that we may find important as we collect data during the initial phases of the testing.

2.2.5 Deliverables

The deliverables for the chemical testing task will be as follows:

1. A construction report for each tank and column test, including the following:

   - Purpose of the test
   - As-built drawings of the test apparatus
   - Chronology of activities up to initiation of the test
   - Documentation of changes in plans or construction details
   - Results of the chemical characterization of starting materials

2. Monthly reports on chemical testing. Each report will be prepared as a technical memorandum. The report will describe all activities completed in the reporting period, identify status of the testing activities with respect to budget and schedule, identify problems that may have arisen and propose solutions, and present data collected and reviewed in the reporting period.

3. Quarterly reports on chemical testing. The quarterly reports will synthesize the monthly reports by presenting an technical analysis of information obtained to date. A comprehensive database will be attached. Each quarterly report will include a QA report prepared by the external QA Officer.

4. Final report. The final report of investigations will present all data obtained in the testing program and will include a technical assessment of the results. The final report will be prepared as a "stand-alone" technical document suitable for both internal and external review.

2.3 SURFACE GEOPHYSICAL PROGRAM

2.3.1 Background

Reconnaissance and detailed geologic studies of the Bingham Creek and Bingham Mine Eastside Dump areas (Smith, 1961,1975; Kennecott, 1984-1988; Callender, 1990) suggest the following:

- There are four major subsurface stratigraphic units in this area (from oldest to youngest): Paleozoic quartzites and limestone (local "basement"); Oligocene volcanics and volcaniclastic rocks (latite flows and flow breccias, lahars, and sandy fluvial interbeds); Miocene lacustrine deposits, mainly clay and silty sand (Jordan Narrows Unit); and Plio-Pleistocene alluvial fan deposits (interbedded sandstone, siltstone, and conglomerate).

- The approximate thicknesses of units overlying the Paleozoic "basement" are as follows: Oligocene volcanics, >1,500'; Jordan Narrows Unit, 0 - >800'; Plio-Pleistocene alluvial fan deposits, 200 - 2,000'.

- The alluvial fan deposits dip 1-5° east into the Jordan Valley; the dip of the Jordan Narrows Unit is unknown; the Tertiary volcanic sequence dips 25-35° east; Paleozoic "basement" dips steeply (>45°) west.

- The water table lies at 100-300' below ground surface; natural water is typically low in conductivity, whereas the groundwater plume in the alluvial fan deposits contains high conductivity, low resistivity fluids (ABC/ASCI, 1990).

- Normal faults probably displace the basement and overlying sediments along the margins of the Oquirrh Mountains; these faults are probably of relatively small vertical displacement (50-500') and may be growth faults that developed coevally with the deposition of Miocene-Pleistocene basin sediments.

Subsurface information in this area is limited to shallow wells and very limited deep well borings (to 1,000'). The geometry and lithology of subsurface stratigraphic units is critical to an understanding of the potential flow units and paths that may exist in the study area. In order to more accurately determine this subsurface fabric, additional subsurface information needs to be collected. A surface geophysical exploration program is proposed to collect additional subsurface information.

2.3.2 Objectives

The surface geophysical program has five major objectives:

1. Determine the orientation, depth, and nature of the contact between alluvial fan deposits and underlying stratigraphic units to establish the thickness and orientation of the alluvial fan unit which contains the groundwater plume.

2. Locate and map with good precision any faults and stratigraphic surfaces that may act as potential pathways for the migration of underground water, or that may influence the distribution and orientation of permeable stratigraphic units.

3. Locate and map the extent of the Jordan Narrows Unit, which may act as an impermeable underlayer to the alluvial fan deposits.

4. Map the lateral and vertical extent of groundwater, both contaminated and uncontaminated.

5. Determine variations in permeability within the alluvial aquifer.

2.3.3 Technical Approach

Three types of surface geophysical surveys will be conducted in the Bingham Creek area to collect information about subsurface structure and plume geometry. These surveys are summarized below; details will be found in Section 2.3.4.

- <u>High resolution seismic reflection</u> on the three lines delineated in Figure 1. Two reflection lines will run east into the Jordan Valley from the Eastside Dumps; the other will run north-south approximately at Utah Highway 111. Target depths will be 200 - 7,000', with vertical resolution of 20 - 50'.

- <u>Time-domain electromagnetic surveys</u> of the Bingham groundwater plume. These surveys will focus on delineating the top and bottom of the plume using electromagnetic techniques; in addition, the base of the alluvial fan sequence will be sounded.

- High resolution seismic refraction will be carried out to obtain a precise location for the top of volcanic basement in the area of the TEM surveys near the Bingham Creek groundwater plume, to define basement depth at the seismic calibration well, to help calibrate the seismic reflection profiling in the same area, and to provide detailed information on stratigraphic layering and faulting in the alluvial fan sediments.

2.3.4 Scope of Work

2.3.4.1 High Resolution Seismic Reflection

Seismic reflection techniques are well established in the oil and environmental areas for subsurface investigations. High resolution, shallow depth surveys are commonly used to explore underground structure in environments like those on Kennecott property. Using methods established elsewhere in the Basin and Range Province, the data acquisition parameters for the seismic reflection survey will be as follows:

- 18.5 miles of high resolution seismic reflection profiling along three lines, two east-west and one north-south (see Figure 1). A deep well will be bored and acoustically logged at the intersection of the northern east-west line and the north-south line (see Section 2.1).

- Minimum 120-channel recording system, with up to 240 channels preferred.

- Single vibrator source, with vibrator sweep of 30 - 150 Hz. Ten sweeps will be conducted per station, with moveup for each sweep. Source spacing is designed to yield 24- to 30-fold data: source array will be one station (55-foot interval), with source array centered on flag. Source interval will be 110 feet in order to yield 30-fold data.

- Geophone group spacing will be 55 feet, with approximately 10 geophones per group. Fundamental frequency response of the geophones will be 25-30 Hz. Phones will be laid between flags, with an asymmetric distribution of phones, 90 groups on one side and 30 groups on other.

- Sample interval will be 2 ms, with Nyquist filters of approximately 2/3 Nyquist (170 Hz).

- Filters or other systems will be used to reject 60-Hz noise.

- All lines will be surveyed, using existing benchmarks.

- Underground pipelines and power lines will be avoided where possible. Where not possible to avoid pipelines, drive level changes or doubling of source points will be used to maintain coverage. Powerline noise will be filtered.

A minimum of one day of field testing will be used to select parameters and to evaluate the operational status of the recording system and source. Simple modeling studies will be done in advance of data acquisition, based on models of the seismo-stratigraphic sequence compiled from geologic and well studies, to determine original parameters for field testing.

After field data acquisition, the data will be processed and interpreted. Downhole acoustic logging will provide velocity parameters for constraining the reflection profiles at the intersection of the north-south and northern east-west lines. Additional profiles will be "hung" on this seismic section.

In addition to the reflection studies described above, a high resolution, shallow (100-1,000') reflection survey will be conducted in an east-west profile from the Bluewater I drainage to Highway 111. This survey will attempt to locate aquitards, including faults, silty and clayey zones, and bedrock. The seismic source is a shaped explosive charge buried 10' deep in the shot hole; the waves are recorded at a sampling rate of 1 ms with low cut filters that exceed 100 Hz.

2.3.4.2 Time-domain Electromagnetic Survey

TEM is used to map changes in electrical conductivity of the subsurface. Changes in conductivity are typically caused by, for example, changes in soil or rock type, the amount of water present, the permeability of a formation, and the conductivity of water in the formation. Since the conductivity of contaminated groundwater in the Bingham Creek plume is at least one order of magnitude greater than that of uncontaminated water (ABC/ASCI, 1990), a surface TEM survey should be able to detect the presence of contaminated groundwater at depths of up to 500 feet in this environment. It is possible that TEM will be able to also map the vertical and horizontal extent of contamination as well as the magnitude of contamination. A basement sounding to determine the depth to the base of the alluvial sequence will also be attempted. The effectiveness of this sounding is premised on the assumption that the base of the alluvium is marked by a change in resistivity due to the presence of either the Jordan Narrows Unit (clay) or Oligocene volcanics (latite flows and breccias). This sounding will be compared to that determined by the seismic reflection survey (Section 2.3.4.1).

The specific objectives of the TEM program are to:

1. Map the lateral and vertical extent of contaminated groundwater.

2. Map variations of permeability within the aquifer to determine whether there are significant zones of silts and clays and whether there are permeability channels.

3. Map the depth to the bottom of the alluvial fan sequence.

4. Map the depth to groundwater over a broad area.

5. Map the changes in contaminant concentration in the groundwater plume.

The TEM survey program consists of four phases:

<u>Phase 1</u>: Obtain conductivity logs of existing wells that penetrate the groundwater plume and the new, deep well to be used to calibrate the seismic reflection survey. Using these logs, create a conductivity profile of the alluvial fan deposits. These logs will also help in the evaluation of the proposed monitor wells on the flanks of the plume (Section 2.1).

<u>Phase 2</u>: Conduct 14 TEM soundings at the well sites used for Phase I above. Using the EM-47 and EM-57 techniques, it will be possible to map changes in conductivity over a depth range of 15 - 1,500' below ground surface.

<u>Phase 3</u>: Conduct seven "basement" soundings to determine depth to bedrock (volcanic, Jordan Narrows Unit, or Paleozoic rocks) beneath the alluvial fan deposits. The seven soundings will be on an east-west line parallel to the northern east-west seismic reflection line and will be centered about the deep seismic calibration hole. Using technique EM-37, changes in conductivity to depths of 3,000' may be measured.

2.3.4.3 Seismic Refraction Survey

Two seismic refraction surveys will be conducted: a north-south line parallel to the north-south seismic reflection line previously noted, and an east-west line from the Bluewater I drainage to Highway 111. Both lines will help to calibrate the seismic reflection studies, particularly depth to volcanics. The seismic source will be mine blasts.

2.3.5 Deliverables

The deliverables for the geophysical surveys will be as follows:

1. Final report on seismic reflection profiling, to include: purpose of program, description of equipment and methods used, raw recording data, processed profiles for three seismic sections, and interpretation of the profiles, including definition of seismo-stratigraphic units, depth to basement, thickness and geometry of the alluvial fan deposits, characterization of the Jordan Narrows Unit, and description of fault and other structural features.

2. Final report on TEM surveys, to include: description of equipment and methods used; detailed conductivity, gamma and geologic logs of the 13 wells tested; conductivity profile at each of the 14 sounding locations; two perpendicular cross-sections through the groundwater plume showing geology, water depth, and geochemistry (if available), conductivity from logging systems, and conductivity from TEM soundings; interpreted conductivity profile and depth to bedrock at location of the seven EM-37 soundings; and interpreted geologic and hydrogeologic cross-sections, using all available data (including gravity, magnetics, induction logs, TEM sounding data, and seismic data).

3. Final report on seismic refraction survey, to include: purpose of program, description of equipment and methods used, raw recording data, processed profiles for two seismic sections, and interpretation of the profiles, including definition and velocities of seismo-stratigraphic units, depth to basement, thickness and geometry of the alluvial fan deposits, characterization of the Jordan Narrows Unit, and description of fault and other structural features.

3.0 QUALITY ASSURANCE PROJECT PLAN

A standard quality assurance program will be developed for the specific needs of this work plan. The plan will contain the following elements:

- Project Description
- Project Organization and Responsibilities
- Quality Assurance Objectives
- Sampling Procedures
- Sample Custody
- Calibration Procedures
- Analytical Procedures
- Data Reduction, Validation, and Reporting
- Internal Quality Control
- Performance and Systems Audit
- Preventative Maintenance
- Data Assessment Procedures
- Corrective Actions
- Quality Assurance Reports

4.0 HEALTH AND SAFETY PLAN

A standard health and safety plan will be developed for the specific needs of this work plan. The plan will contain the following elements:

- Organization
- Health and Safety Risk Analysis
- Employee Training
- Personal Protective Equipment
- Medical Surveillance Requirements
- Site Monitoring Requirements
- Site Control Measures
- Decontamination Procedures
- Standard Operating Procedures for the Site
- Site Contingency Plan
- Entry Procedures for Confined Spaces

PROJECT PLANS
FOR
STATE MOTORCYCLE PARK TAILINGS
SITE CHARACTERIZATION

SALT LAKE COUNTY, UTAH

Report 1212H/910624
June 24, 1991
Printed: June 27, 1991 9:30pm

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1.0 OVERALL WORKPLAN

1.1 INTRODUCTION/BACKGROUND STATEMENT

The State Motorcycle Park Tailings site is located just east of the town of Lark. The tailings were generated from copper ores from the Mascotte Mine and were deposited between 1909 and 1918 by the Ohio Copper Company. The original mill site was on a ridge east of Utah Highway 111. From 1937 to 1950, some of the the tailings were reprocessed by the Ohio Copper Company, and discharged on the east side of the site. The Ohio Copper Company was a predecessor to U.V. Industries. In 1977 Kennecott leased the site to the Utah State Division of Parks and Recreation for use as a motorcycle park, an activity that continued until 1989 (Kennecott, 1991). Kennecott has never operated any mines or mills at this site.

The site contains approximately 470 acres, of which 350 acres are covered with mill tailings and associated debris. There are approximately 5,000,000 tons of tailings located in two primary areas, the upper (eastern) area covers about 163 acres, and the lower (western) area covers about 186 acres (Kennecott, 1991). The tailings were revegetated prior to 1977, but, this vegetation was severely impacted during the site's use as a motorcycle park (Kennecott, 1991).

The tailings have not been maintained in a condition to prevent particulate transport, and airborne dispersion of tailings has been noted by the EPA (EPA, 1990). Evidence of windblown and drifted tailings can be seen on site. However, reclamation of the State Motorcycle Park was started on February 26, 1990, using a seed drill. Seeding was mostly complete by March 14, 1990 with the planting of a grass legume species. Excelsior matting was used to test stabilization of the tailings area, which retains moisture and adds organic matter as the matting degrades over about a two-year period. Five species of shrubs were planted by pulling a discing tree planter to create wind-rows on both the north and south ends of the area, as well as the perimeter of the original pond site.

The tailings have the potential to impact off-site soils. Copper from the tailings has been meteorically leached from the tailings and redeposited in the soil beneath the tailings. Acidic seepage from the tailings has migrated into the subsoil, but the buffering capacity of the soils has neutralized this acidity and precipitated iron and copper in the first few feet below the tailings (ASCI/ABC, 1990). Total metals analyses were conducted on 56 tailings and soils samples at the site. Table 1 shows a statistical summary of the regulated metals concentrations for these samples.

Table 1. State Motorcycle Park Tailings Solids Total Metals Analyses (ppm)

Element	Average Conc. (ppm)	Minimum Conc. (ppm)	Maximum Conc. (ppm)	Standard Deviation	Samples Below Detect.	Detection Level (ppm)
Arsenic	247	59	743	144	0	
Barium	118	19	238	69	0	
Cadmium	5.9	1	24	4.5	1	1
Chromium	21	<1	57	17	1	1
Lead	66	<1	501	85	6	1
Selenium	59	11	165	33	0	
Silver	1.6	<1	3	0.68	3	1

Source: ASCI/ABC, 1990

Acid generation may adversely affect ground and surface water quality in the area. The actual impact to surface water from the site is not known, since surface water data is not available in the site area. Surface water from active KUC southern mine dumps and from Bingham Tunnel discharge are now routed away from the State Motorcycle Park site. The site is located on a recharge area for the deep semiconfined to unconfined aquifer system (EPA, 1990). The potential for groundwater contamination exists from seepage through the tailings. Previously collected groundwater data demonstrates similar metals concentrations for wells upgradient and downgradient of the site.

1.2 OBJECTIVES

The objective of the proposed environmental response program is to characterize the tailings. Environmental actions considered for this site consist of direct revegetation of the tailings, covering the tailings prior to revegetation, or a combination of the two (Kennecott, 1991). In addition, selected areas of tailings would be considered for relocation.

Key geochemical and engineering items to be assessed during site characterization include the following:

1. Characterization of the geochemistry of the tailings by depth and location to assess which areas may need to be reclaimed by direct revegetation and which areas may require more thorough capping. The reprocessed tailings may (for example) be more amenable to direct revegetation than the original tailings.

2. Assessment of the depths of migration of metals and other constituents in the tailings fluids beneath the tailings, and the magnitude of attenuation of these constituents by the site subsoils.

3. Clarification of the depths and volume of tailings. The backhoe trenches excavated in 1990 in the eastern area of the site (ASCI/ABC, 1990) did not reach the bottom of the tailings. Some of the reprocessed tailings was therefore not sampled.

4. Assessment of the bearing capacity of the tailings to vehicle traffic for topsoil placement and revegetation. Observations in 1990 were that most of the areas could be accessed with rubber-tired vehicles. However, some of the tailings in low areas were sufficiently wet to prevent rubber-tired vehicle traffic, and special procedures or equipment may be required for topsoil placement or revegetation.

5. Assessment of migration of the tailings off site by erosion or windborne transport.

1.3 SCOPE

The key items listed above as well further assessment of the environmental impact of the tailings are addressed by the following site characterization tasks.

1. Excavation of approximately 20 backhoe trenches through the tailings into underlying subsoils and into adjacent background soil areas. Samples of tailings, underlying soils, downstream sediments, and background soils will be collected.

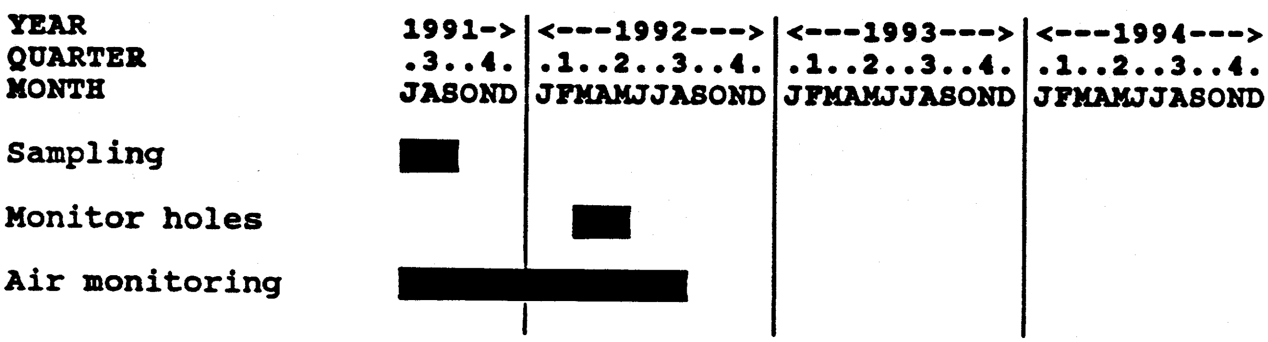
2. Drilling of approximately 20 auger holes through the tailings into underlying subsoils. Samples of tailings and underlying soils will be collected.

3. Drilling and installation of two groundwater monitoring wells in the site area. Soil and groundwater samples will be collected.

4. Installation and startup of an air monitoring station.

Selected samples collected from this program will be analyzed for geochemical and geotechnical characteristics.

1.4 WORK SCHEDULE



1.5 DELIVERABLES

The deliverables for the project will be as follows:

1. A report describing the results of the 1991-92 field program, integrating the information gained with prior information collected and reported, including air quality, groundwater quality, and soil quality. This report will follow the general outline of a site characterization report (Table 2).

2. Individual reports for the major program components, including solids sampling, geochemical testing, and air/water sampling programs, as noted in Section 2, below. These reports would include a description of the field sampling and testing, presentation of laboratory analysis results, and other pertinent documentation.

Table 2. Site Characterization Report Format

1.6 REFERENCES

Adrian Brown Consultants, Inc., 1991a, Quality Assurance Project Plan for Kennecott Utah Copper Environmental Actions: Contractor Report to Kennecott Corporation, June, 33 p., 4 appendices.

Adrian Brown Consultants, Inc., 1991b, Health and Safety Plan for Kennecott Utah Copper Environmental Actions: Contractor Report to Kennecott Corporation, June, 14 p., 2 appendices.

Adrian Smith Consulting Inc. and Adrian Brown Consultants, 1990, Geochemical evaluation of Lark tailings, Lark, Utah, Contractor Report to Kennecott Corporation, October, 12 p.

EPA, 1986, Test Methods for Evaluating Solid Waste, SW-846, Third Edition, U.S. Environmental Protection Agency, Washington D.C., two volumes.

EPA, 1988, Guidance for conducting remedial investigations and feasibility studies under CERCLA: Interim Final Report, OWSER Directive 9355.3-01, EPA/540/G-89/004, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, October, 120 p., 6 appendices.

EPA, 1990, CERCLA file information, State Motorcycle Park, December.

Kennecott Corporation, 1991, Kennecott Utah Copper Environmental Response, State Motorcycle Park, April 11.

2.0 FIELD SAMPLING PLAN

2.1 SOLIDS EVALUATION PROGRAM

2.1.1 Background

The environmental response report for the Motorcycle Park (Kennecott, 1991) summarized available environmental data for the site and outlined several alternatives for remediation of the site. To more clearly define the impact of the site and assess potential remediation alternatives, additional sampling and analyses are outlined.

2.1.2 Objectives

As outlined in Section 1.2, the objectives of the project plan are to clarify the spatial variations of the depth and geochemistry of the tailings. These objectives are primarily related to additional excavation and drilling into tailings and underlying subsoils. This work is done to assess the geochemistry of the types of tailings, and to assess how far constituents from the tailings water have migrated into the underlying subsoils.

2.1.3 Technical Approach

Approximately 20 backhoe trenches will be excavated through the tailings into underlying subsoils and into adjacent background soil areas. Samples of tailings, underlying soils, downstream sediments, and background soils will be collected.

Based on the results of sampling in 1990 (ASCI/ABC, 1990), much of the reprocessed tailings are deeper than can be reached with a backhoe. In areas of deeper tailings, drilling of approximately 20 auger holes through the tailings into underlying subsoils is planned. The anticipated number of backhoe trenches and auger holes should give adequate coverage of the tailings for the objectives described above.

Drilling will be done with a hollowstem auger rig, and sampling conducted with a dry-core sampler. Depths of drilling will be generally within approximately five feet of the bottom of the tailings. However, a few holes will be drilled up to 20 feet into the subsoils for attenuation testing samples.

Samples of tailings and soils will be collected representing key components of the profile with depth. Selected samples will be analyzed for geochemical and geotechnical parameters. A selected group of approximately 20 to 30 percent of the collected samples will be analyzed initially. Additional samples would be analyzed if additional clarification is needed, based on the initial analysis results.

2.1.4 Sampling and Analyses

Sampling will be conducted in a manner similar to that conducted on site in 1990 (ASCI/ABC, 1990). This will include detailed logging of material type, color, and other distinguishing characteristics for correlation with lab analyses to identify metalliferous minerals in the tailings or underlying subsoils. Sample labeling would be by trench or drill hole number, depth of sampling interval, and sample split number.

Sample handling would be conducted in a manner consistent with Standard Operating Procedures for sampling. These methods are consistent with EPA-prescribed sampling procedures (EPA, 1986). Sample tracking will be documented by use of chain-of-custody forms.

Samples will be analyzed for geochemical tests, including: acid generation potential, leachability of metals (EPA Method 1312), and total metals analysis. Where appropriate, selected geotechnical tests will conducted, including: grain-size distribution, moisture content, and density.

2.1.5 Deliverables

The deliverables for the solids evaluation task will consist of a final site characterization report. The final report of investigations will present all quality assured data obtained in the testing program and will include a technical assessment of the results. The final report will be prepared as a "stand-alone" technical document.

2.2 GROUNDWATER MONITORING PROGRAM

2.2.1 Background

The environmental response report for the Motorcycle Park (Kennecott, 1991) summarized available environmental data and indicates that the potential for groundwater contamination exists at this site. Data available at this time does not indicate that groundwater contamination has occurred, however, the site has not been fully investigated. Therefore, to more clearly define the impact of the site and assess potential remediation alternatives, additional groundwater characterization is outlined.

2.2.2 Objectives

The objective of the drilling is to determine specific groundwater information, define the extent of contamination, and quantify the contribution from the Motorcycle Park tailings. In order to achieve these objectives, the drilling program has been designed to provide several different sample types, each requiring different drilling, handling, and analyses.

2.2.3 Technical Approach

Two holes will be drilled to accomplish the objectives listed above; each hole is described in detail below.

The drilling style employed in this program will be reverse-air, which provides relatively unaffected solid samples are required, as well as providing water chemistry data through a given interval.

Reverse-air drilling will be performed with double-walled drill pipe and appropriate bit. Fluids (water) will not be used with this drilling method, except when necessary due to poor returns, which usually occurs near the water table. Once sufficient formation water is produced, injection of water is not necessary.

Monitoring Wells

Drilling/Completion:

1. After installing surface casing, drill 6-inch hole to 500 feet by reverse-air.
2. Mud hole and geophysically log the entire hole.

3. Install 500 feet of 2-inch PVC, sched 80 pipe, the bottom 100 feet of which is screen.

4. Using a tremmie pipe, sand pack screen area with approximately 120 feet of silica sand.

5. Using a tremmie pipe, seal remaining annulus to with Pure-gold to within 30 feet of surface.

6. Cement upper 30 feet of hole and install protective casing and locking cap.

7. Develop by air-lifting.

Data will be collected as follows:

1. Drill cuttings will be logged continuously.

2. Drill cutting samples will be collected every five feet.

3. Formation fluid field parameters (e.g., pH, conductivity) will be measured every five feet during reverse-air drilling.

4. Water samples will be collected in the reverse-air drilled portion of each hole every 20 feet and a water sample will be collected after completion of the monitoring well.

5. The following geophysical tools will be run after drilling to total depth: gamma ray, neutron, density, induction, micro-resistivity, spontaneous potential, caliper, and temperature. These logs will provide geologic, hydrologic, and geochemical information with depth such as lithology, porosity, hydraulic conductivity, permeability, and water quality.

6. A single well permeability test may be conducted at each well, depending upon the need for additional permeability data at these.

2.2.4 Sampling Methods

2.2.4.1 Sample location and frequency

Several different sample types will be collected during the course of the drilling investigation, such as:

1. Drill cuttings - reverse-air
2. Drive samples
3. Formation water - field parameters (during reverse-air drilling)
4. Formation water - chemical analysis (during reverse-air drilling)
5. Formation water - at the end of well development

2.2.4.2 Sample designation

All samples collected from the various drill holes will be numbered in a manner consistent with previous drilling. Samples will be identified by the hole number, the depth, W for water samples, and the sample date. Solid sample numbers will appear the same, except will not include the letter W.

2.2.4.3 Sampling equipment and procedures

Each sample type will require specific equipment and procedures, which will be outlined in various Standard Operating Procedures (SOP). The following provides a list of SOP's which specifically deal with collection of the various sample types:

1. SOP-100: Collection and handling of drill cuttings: Mud-rotary
2. SOP-101: Collection and handling of drill cuttings: Reverse-air
3. SOP-102: Collection and handling of drive samples
4. SOP-103: Collection of groundwater samples for analysis
5. SOP-104: Preparation of water samples for analysis
6. SOP-105: Solid sample splitting

The SOP's referenced in this document will be provided in a Quality Assurance Program Plan.

2.2.4.4 Sample handling and analysis

Sample handling for each of the anticipated sample types will be discussed in the SOP's listed above. Sample handling will include bagging, transportation, splitting, routing, and storage. The analyses to be performed as part of the groundwater plume study are summarized in Table 3.

Table 3. Chemical Parameters for Groundwater Plume Analyses

PARAMETER	GROUNDWATER	SOLIDS
Acidity/Alkalinity	T	NA
Available Neutralization Potential	NA	T
pH	T	Paste
Specific Conductance	T	Paste
TDS	T	NA
Ca	T	TD; L
Mg	T	TD;L
Na	T	TD; L
K	T	TD; L
HCO3/CO3	T	NA
Cl	T	NA
SO_4	T	TD; L
B	T	Na
Li	T	TD
Sr	T	TD
F	T	NA
$NO_3 + NO_2$	T	NA
As	D	TD
Ba	D	TD
Cd	D	TD
Cr (Total)	D	TD
Co	D	TD
Cu	D	TD
Fe	D	TD
Pb	D	TD

PARAMETER	GROUNDWATER	SOLIDS
Mn	D	TD
Se	D	TD
Ag	D	TD
Zn	D	TD
Gross Alpha	D	NA
Gross Beta	D	NA
Ra-226+228	D	NA
U	D	NA

1. D: Dissolved
   T: Total
   TD: Total Digestible
   L: Leachable
   NA: Not Applicable to this phase

2. Analyses will be performed using the procedures of USEPA, 1986, Test methods for Evaluating Solid Waste, Physical/Chemical Methods: SW-846, third edition, except as follows:

   The following tests will be performed using the test procedures developed by KEL/ABC in 1990:

   - o Available Neutralization Potential
   - o Leachable Sulfate and Leachable Cations

   These test methods are presented in ABC, 1990, Laboratory Test Results... In addition, the test procedures are on file with KEL, where they are available for review on reasonable notice.

3. Minimum detection limits will be those of the EPA Contract Laboratory Program Routine Analytical Services, except that the detection limit for ANP will be 10 mg $CaCO_3$ equivalent per kg solid, and the detection limit for Leachable Species will be 10 mg/kg.

2.2.4.5 Sample Paperwork

Traffic reports. Traffic reports will not be used in this project. Chain of custody forms will be used to track the progress of the various samples.

Chain of custody form. A chain of custody form will be used in all circumstances.

SAS packing list. SAS packing list does not apply to this program.

Sample tags. Sample tags consistent with the previous drilling program will be used. The specific labeling procedures will be outlined in the various SOP's.

2.2.5 Deliverables

A well report will be produced for each well drilled, and will include the following:

1. Purpose of the well
2. Description of drilling and completion activities
3. Geologic description and pictorial log of the hole
4. Geophysical logs of the hole (if any)
5. Description of the sampling performed
6. Results of sampling/testing at the well site
7. Results of laboratory testing (when available)
8. Results of any hydraulic testing

2.3 AIR MONITORING PROGRAM

2.3.1 Background

Because particulates from the State Motorcycle Park Tailings area are potentially of concern, an air monitoring station is proposed for the tailings vicinity.

2.3.2 Objectives

The objective of this program is to monitor particulates in the vicinity of the tailings to establish whether material is leaving the pond area via the atmosphere. If particulates are leaving the tailings area, an air station will establish the nature and quantity of material in transit.

2.3.3 Technical Approach

A visual assessment of windborne particulates which are currently generated from the tailings, and an assessment of the potential effects of remediation on windborne particulates will be used to establish the location of the air monitoring station and define the monitoring program. One project-specific local monitoring station will be located between the evaporation ponds and the closest residential area, based on the prevailing wind direction and an available site.

Air monitoring will consist of particulate measurement using an air filtering device. Particles collected on the filter will be weighed and analyzed for specific metals. Air gases will not be monitored. Related parameters, such as wind speed and direction, precipitation, and temperature will also be measured and recorded at the monitoring station.

2.3.4 Scope of Work

The initial task is the installation of the monitoring station. Monitoring will be on a regular frequency, yet to be determined, and will continue through site characterization. Particles will be collected on 24-hour basis.

2.3.6 Deliverables

An air monitoring report, describing the monitoring station installation and presenting monitoring data and results through the site characterization, will be prepared.

3.0 QUALITY ASSURANCE PROJECT PLAN

A standard quality assurance program will be developed for the specific needs of this work plan. The plan will contain the following elements:

- Project Description
- Project Organization and Responsibilities
- Quality Assurance Objectives
- Sampling Procedures
- Sample Custody
- Calibration Procedures
- Analytical Procedures
- Data Reduction, Validation, and Reporting
- Internal Quality Control
- Performance and Systems Audit
- Preventative Maintenance
- Data Assessment Procedures
- Corrective Actions
- Quality Assurance Reports

4.0 HEALTH AND SAFETY PLAN

A standard health and safety plan will be developed for the specific needs of this work plan. The plan will contain the following elements:

- Organization
- Health and Safety Risk Analysis
- Employee Training
- Personal Protective Equipment
- Medical Surveillance Requirements
- Site Monitoring Requirements
- Site Control Measures
- Decontamination Procedures
- Standard Operating Procedures for the Site
- Site Contingency Plan
- Entry Procedures for Confined Spaces

PROJECT PLANS
FOR
LARK WASTE ROCK
SITE CHARACTERIZATION

SALT LAKE COUNTY, UTAH

Report 1212G/910623
June 23, 1991
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1.0 OVERALL WORKPLAN

1.1 INTRODUCTION/BACKGROUND STATEMENT

The Lark Waste Rock Site consists of several abandoned mine waste dumps located directly east and north of the town of Lark. The waste rock originated from mining operations conducted in the late 1800s and early 1900s. There are approximately 1,300,000 cubic yards of waste rock located at the site, occupying approximately 40 acres (Kennecott, 1991). The waste rock is distributed in three large, primary dumps and three smaller secondary dumps adjacent to Highway 111 (Figure 1). The three primary dumps are named, due to their shape, the Round Dump, Long Dump, and Miscellaneous Dump (ASCI/ABC, 1990).

Mining operations began at the Lark Mine in the late 1800's. In 1909, the Mascotte Tunnel was constructed by the Bingham Central Railway to remove lead-zinc-silver ores from the Lark and Ohio Copper Company mines. Waste rock from the Mascotte Tunnel and Ohio Copper Company's mine in Bingham Canyon was placed in the Long Dump. Waste from the Lark Mine was placed in the Miscellaneous Dump. The Bingham Tunnel was constructed to provide a second access adit to the Lark Mine in about 1950. Waste rock from the Bingham Tunnel and the most recent Lark Mine waste was placed in the Round Dump (Kennecott, 1991). The Ohio Copper Company, Bingham Central Railroad, Mascotte Tunnel, Bingham Tunnel, and Lark Mine were all operated by predecessors to U.V. Industries. While Kennecott currently owns the land on which the dumps are located, it has never operated either a mine or mill near the town of Lark.

Migration of waste materials by air is limited due to the size of the rock fragments from the waste materials on site. However, the waste piles are not maintained in a condition to prevent particulate transport and dust has been observed blowing in the vicinity of the dumps (Kennecott, 1991).

The dumps have the potential to impact off-site soils. The three primary dumps have been sampled and were found to contain both oxidized and unoxidized materials. Total metals analyses were conducted on several waste areas at the site, and show measurable concentrations of copper, iron, lead, and zinc (EPA, 1990). Acid generation potential testing indicates that the unoxidized materials from the Long and Round dumps are acid generating and leach low to moderate levels of selected metals species. There is evidence of attenuation of copper, zinc and cadmium by the site soils (ASCI/ABC, 1990).

Acid generation may adversely affect ground and surface water quality in the area. Elevated metals concentrations have been found in surface water downstream from the Lark Waste Rock site. The actual impact and quantity attributable to the Lark site alone is not known. The site is located on a recharge area for the deep semiconfined to unconfined aquifer system (EPA, 1990). The potential for groundwater contamination exists from seepage through the waste materials. Previously collected groundwater data demonstrates similar metals concentrations for wells upgradient and downgradient of the site.

1.2 OBJECTIVES

The objective of the proposed environmental response program is to characterize the waste rock. Environmental actions considered for this site consist of either in-place remediation or removal of the waste rock. In-place remediation would include regrading the waste dumps, capping with clay and topsoil, and revegetation. Removal would include excavation of waste rock and affected underlying soils and placement in the Crapo/North Keystone Canyon disposal facility (Kennecott, 1991).

Key geochemical and engineering items to be assessed during site characterization include the following:

1. Characterization of the geochemistry of the waste rock by depth and individual dump to assess which waste rock may be reclaimed by capping and which waste rock may require removal.

2. Assessment of the depths of migration of metals and other constituents leached from the waste rock into underlying subsoils, and the magnitude of attenuation of these constituents by the site subsoils.

3. Clarification of the depths and volume of waste rock. The majority of backhoe trenches excavated in 1990 (ASCI/ABC, 1990) were along the edge of the dumps. The backhoe trenches in 1990 were excavated in primarily oxidized materials. Waste rock at depth in the dumps (that may not be oxidized) was not sampled.

4. Assessment of migration of waste rock materials from the dumps by erosion.

1.3 SCOPE

The key items listed above as well as further assessment of the environmental impact of the waste dumps are addressed by the following site characterization tasks.

1. Excavation of approximately 20 backhoe trenches through the waste rock into underlying subsoils and into adjacent background and downstream soil areas. Samples of waste rock, underlying soils, downstream sediments, and background soils will be collected.

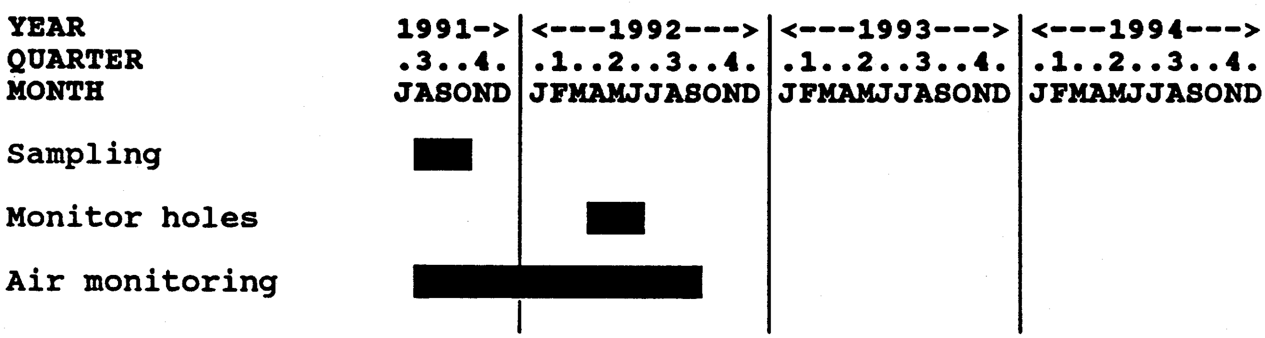
2. Drilling of approximately 20 auger holes through the waste rock into underlying subsoils. Samples of waste rock and underlying soils will be collected.

3. Drilling and installation of three groundwater monitoring wells in the site area. Soil and groundwater samples will be collected.

4. Installation and startup of an air monitoring station.

Selected samples collected from this program will be analyzed for geochemical and geotechnical characteristics.

1.4 WORK SCHEDULE



1.5 DELIVERABLES

The deliverables for the project will be as follows:

1. A site characterization report describing the results of the 1991-92 field program, integrating the information gained with prior information collected and reported, including air quality, groundwater quality, and soil quality. This report will follow the general outline of a site characterization report, and will be similar to that set out in Table 1.

2. Individual reports for the major program components, including solids sampling, geochemical testing, and air/water sampling programs, as noted in Section 2, below. These reports would include a description of the field sampling and testing, presentation of laboratory analysis results, and other pertinent documentation.

Table 1. Site Characterization Report Format

1.6 REFERENCES

Adrian Smith Consulting Inc., and Adrian Brown Consultants, Inc., 1990, Initial geochemical evaluation of materials in four mine waste areas near Lark, Utah, Contractor report to Kennecott Corporation, October.

Adrian Brown Consultants, Inc., 1991a, Quality Assurance Project Plan for Kennecott Utah Copper Environmental Actions: Contractor Report to Kennecott Corporation, June, 33 p., 4 appendices.

Adrian Brown Consultants, Inc., 1991b, Health and Safety Plan for Kennecott Utah Copper Environmental Actions: Contractor Report to Kennecott Corporation, June, 14 p., 2 appendices.

EPA, 1986, Test Methods for Evaluating Solid Waste, SW-846, Third Edition, U.S. Environmental Protection Agency, Washington D.C., two volumes.

EPA, 1988, Guidance for conducting remedial investigations and feasibility studies under CERCLA: Interim Final Report, OWSER Directive 9355.3-01, EPA/540/G-89/004, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, October, 120 p., 6 appendices.

EPA, 1990, CERCLA file information, Lark Tailings, December.

Kennecott Corporation, 1991, Kennecott Utah Copper Environmental Response, Lark Waste Rock (CERCLIS title: Lark Tailings), April 11.

2.0 FIELD SAMPLING PLAN

2.1 SOLIDS EVALUATION PROGRAM

2.1.1 Background

The environmental response report for the waste rock dumps (Kennecott, 1991) summarized available environmental data for the site and outlined several alternatives for remediation of the site. To more clearly define site conditions, additional sampling and analyses are planned.

2.1.2 Objectives

As outlined in Section 1.2, the objectives of the project plan are to clarify the spatial variation of the depth and geochemistry of the waste rock. The objectives are primarily related to additional excavation and drilling into waste rock and underlying subsoils. This work is done to assess the geochemistry of the types of waste rock, and to assess how far constituents leached from the waste rock have migrated into the underlying subsoils.

2.1.3 Technical Approach

Approximately 20 backhoe trenches will be excavated through the waste rock into underlying subsoils and into adjacent background soil areas. Samples of waste rock, underlying soils, downstream sediments, and background soils will be collected.

Based on the results of sampling in 1990 (ASCI/ABC, 1990), much of the waste rock is deeper than can be reached with a backhoe. In areas of deeper waste rock, drilling of approximately 20 auger holes through the waste rock into underlying subsoils is planned. The anticipated number of backhoe trenches and auger holes should give adequate coverage of the waste rock dumps for the objectives described above.

Drilling will be done with a hollowstem auger rig, and sampling conducted with a dry-core sampler. Depths of drilling will be generally within approximately five feet of the bottom of the waste rock. However, a few holes will be drilled up to 20 feet into the subsoils for attenuation testing samples.

Samples of waste rock and soils will be collected, representing key components of the profile with depth. Selected samples will be analyzed for geochemical and geotechnical parameters. A selected group of approximately 20 to 30 percent of the collected samples will be analyzed initially. Additional samples would be analyzed if additional clarification is needed, based on the initial analysis results.

2.1.4 Sampling and Analyses

Sampling will be conducted in a manner similar to that conducted on site in 1990 (ASCI/ABC, 1990). This will include detailed logging of material type, color, and other distinguishing characteristics for correlation with lab analyses to identify metalliferous minerals in the waste rock or underlying subsoils. Sample labeling would be by trench or drill hole number, depth of sampling interval, and sample split number.

Sample handling would be conducted in a manner consistent with the Standard Operating Procedures for sampling. These methods are consistent with EPA-prescribed sampling procedures (EPA, 1986). Sample tracking will be documented by use of chain-of-custody forms.

Samples will be analyzed with geochemical tests, including: acid generation potential, leachability of metals (EPA Method 1312), and total metals analysis. Where appropriate, selected geotechnical tests will be conducted, including: grain-size distribution, moisture content, and density.

2.1.5 Deliverables

The deliverables for the solids evaluation task will consist of a final site characterization report. The final report of investigations will present all quality assured data obtained in the testing program and will include a technical assessment of the results. The final report will be prepared as a "stand-alone" technical document.

2.2 GROUNDWATER MONITORING PROGRAM

2.2.1 Background

Based on available data, it is not clear whether the waste rock piles have contributed any contaminants to the local groundwater. Therefore, to more clearly define the impact of the site and assess potential remediation alternatives, additional groundwater characterization is outlined.

2.2.2 Objectives

The objective of the drilling is to determine specific groundwater information, define the extent of contamination, and quantify the contribution from the waste rock dumps. The drilling program has been designed to provide several different sample types, each requiring different drilling, handling, and analyses.

2.2.3 Technical Approach

Three holes will be drilled to accomplish the objectives listed above. Figure 1 shows the expected location of the drill holes, and each hole is described in detail below.

The drilling style employed in this program will be reverse-air. Reverse-air is used where relatively unaffected solid samples are required, as well as providing water chemistry data through a given interval.

500 foot Monitoring Wells (3)

Drilling/Completion:

1. After installing surface casing, drill 6-inch hole to 500 feet by reverse-air.

2. Mud hole and geophysically log the entire hole (see list provided below for geophysical tools to be used).

3. Install 500 feet of 2-inch PVC, sched 80 pipe, the bottom 100 feet of which is screen.

4. Install approximately 120 feet of silica sand in the screen interval.

5. Seal remaining annular space with Pure-gold to within 30 feet of surface.

6. Cement upper 30 feet of hole and install protective casing and locking cap.

7. Develop by air-lifting.

8. Geophysically log cased hole upon completion (see list provided below for geophysical tools to be used).

Data will be collected as follows:

1. Drill cuttings will be logged continuously.

2. Drill cutting samples will be collected every five feet.

3. Formation fluid field parameters (e.g., pH, conductivity) will be measured every five feet during reverse-air drilling.

4. Water samples will be collected in the reverse-air drilled portion of each hole every 20 feet and a water sample will be collected after completion of the monitoring well.

5. The following geophysical tools will be run after drilling to total depth: gamma ray, neutron, density, induction, micro-resistivity, spontaneous potential, caliper, and temperature. An additional suite of logs (gamma ray, induction, and neutron) will be collected after completion of the monitoring well. These logs will provide geologic, hydrologic, and geochemical information with depth such as lithology, porosity, hydraulic conductivity, permeability, and water quality.

6. A single well permeability test may be conducted at each well, depending upon the need for additional permeability data at these.

Reverse-air drilling will be performed with double-walled drill pipe and appropriate bit. Fluids (water) will not be used with this drilling method, except when necessary due to poor returns, which usually occurs near the water table. Once sufficient formation water is produced, injection of water is not necessary.

2.2.4 Sampling Methods

2.2.4.1 Sample location and frequency

Several different sample types will be collected during the course of the drilling investigation, such as:

1. Drill cuttings - reverse-air
2. Drive samples
3. Formation water - field parameters (during reverse-air drilling)
4. Formation water - chemical analysis (during reverse-air drilling)
5. Formation water - at the end of well development

2.2.4.2 Sample designation

All samples collected from the various drill holes will be numbered in a manner consistent with previous drilling. Samples will be identified by the hole number, the depth, W for water samples, and the sample date. Solid sample numbers will appear the same, except will not include the letter W.

2.2.4.3 Sampling equipment and procedures

Each sample type will require specific equipment and procedures, which will be outlined in various Standard Operating Procedures (SOP). The following provides a list of SOP's which specifically deal with collection of the various sample types:

1. SOP-100: Collection and handling of drill cuttings: Mud-rotary
2. SOP-101: Collection and handling of drill cuttings: Reverse-air
3. SOP-102: Collection and handling of drive samples
4. SOP-103: Collection of groundwater samples for analysis
5. SOP-104: Preparation of water samples for analysis
6. SOP-105: Solid sample splitting

The SOP's referenced in this document will be provided in a Quality Assurance Program Plan.

2.2.4.4 Sample handing and analysis

Sample handling for each of the anticipated sample types will be discussed in the SOP's listed above. Sample handling will include bagging, transportation, splitting, routing, and storage. The analyses to be performed as part of the groundwater plume study are summarized in Table 2.

2.2.4.5 Sample Paperwork

Traffic reports. Traffic reports will not be used in this project. Chain of custody forms will be used to track the progress of the various samples.

Chain of custody form. A chain of custody form will be used in all circumstances.

SAS packing list. SAS packing list does not apply to this program.

Sample tags. Sample tags consistent with the previous ABC drilling program will be used. The specific labeling procedures are outlined in SOP-104 (Sample labeling).

Table 2. Chemical Parameters for Groundwater Plume Analyses

PARAMETER	GROUNDWATER	SOLIDS
Acidity/Alkalinity	T	NA
Available Neutralization Potential	NA	T
pH	T	Paste
Specific Conductance	T	Paste
TDS	T	NA
Ca	T	TD; L
Mg	T	TD;L
Na	T	TD; L
K	T	TD; L
HCO3/CO3	T	NA
Cl	T	NA
SO_4	T	TD; L
B	T	Na
Li	T	TD
Sr	T	TD
F	T	NA
$NO_3 + NO_2$	T	NA
As	D	TD
Ba	D	TD
Cd	D	TD
Cr (Total)	D	TD
Co	D	TD
Cu	D	TD
Fe	D	TD
Pb	D	TD

PARAMETER	GROUNDWATER	SOLIDS
Mn	D	TD
Se	D	TD
Ag	D	TD
Zn	D	TD
Gross Alpha	D	NA
Gross Beta	D	NA
Ra-226+228	D	NA
U	D	NA

1. D: Dissolved
   T: Total
   TD: Total Digestible
   L: Leachable
   NA: Not Applicable to this phase

2. Analyses will be performed using the procedures of USEPA, 1986, Test methods for Evaluating Solid Waste, Physical/Chemical Methods: SW-846, third edition, except as follows:

   The following tests will be performed using the test procedures developed by KEL/ABC in 1990:

   - Available Neutralization Potential

   - Leachable Sulfate and Leachable Cations

   These test methods are presented in ABC, 1990, Laboratory Test Results... In addition, the test procedures are on file with KEL, where they are available for review on reasonable notice.

3. Minimum detection limits will be those of the EPA Contract Laboratory Program Routine Analytical Services, except that the detection limit for ANP will be 10 mg $CaCO_3$ equivalent per kg solid, and the detection limit for Leachable Species will be 10 mg/kg.

2.2.5 Deliverables

A well report will be produced for each well drilled, and will include the following:

1. Purpose of the well
2. Description of the drilling and completion a
3. Geologic description and pictorial log of the hole
4. Geophysical logs of the hole (if any)
5. Description of the sampling performed
6. Results of the sampling/testing at the well site
7. Results of laboratory testing (when available)

2.3 AIR MONITORING PROGRAM

2.3.1 Background

Because particulates from the waste rock area are potentially of concern, an air station is proposed for the waste rock vicinity.

2.3.2 Objectives

The objective of this program is to monitor particulates in the vicinity of the waste rock piles to establish whether material is leaving the pile area via the atmosphere. If particulates are leaving the pile area, an air station will establish the nature and quantity of material in transit.

2.3.3 Technical Approach

A visual assessment of windborne particulates which are currently generated from the waste rock piles, and an assessment of the potential effects of remediation on windborne particulates will be used to establish the location of the air monitoring station and define the monitoring program. One project-specific local monitoring station will be located between the waste rock piles and the closest residential area, based on the prevailing wind direction and an available site.

Air monitoring will consist of particulate measurement using an air filtering device. Particles collected on the filter will be weighed and analyzed for specific metals. Related parameters, such as wind speed and direction, precipitation, and temperature will also be measured and recorded at the monitoring station.

2.3.4 Scope of Work

The initial task is the installation and setup of the monitoring station. Monitoring will be on a regular frequency, yet to be determined, and will continue through site characterization. Particles will be collected on a 24-hour basis.

2.3.5 Deliverables

An air monitoring report, will be produced, describing the monitoring station installation, presenting monitoring data and results through site characterization.

3.0 QUALITY ASSURANCE PROJECT PLAN

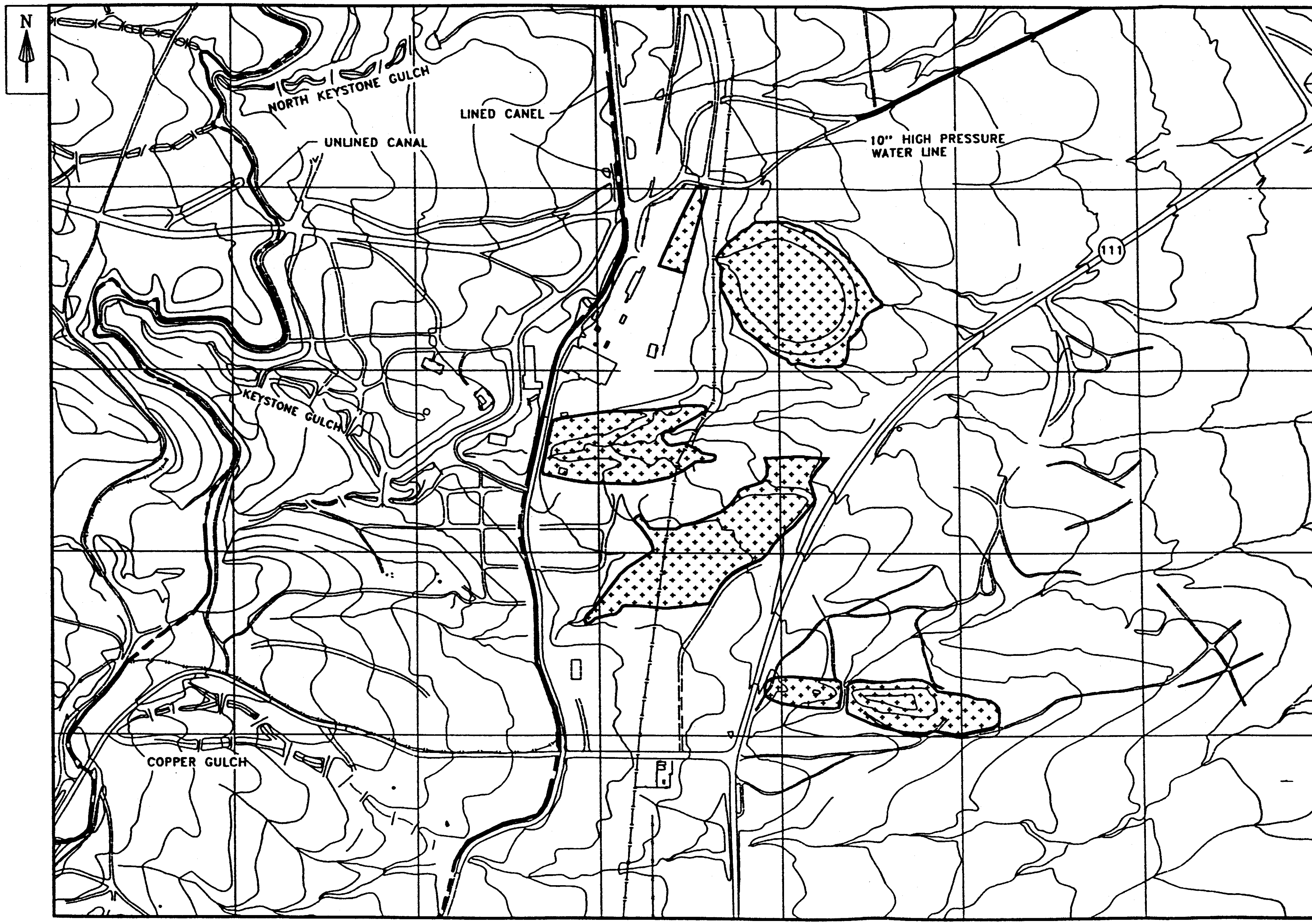
A standard quality assurance program will be developed for the specific needs of this work plan. The plan will contain the following elements:

- Project Description
- Project Organization and Responsibilities
- Quality Assurance Objectives
- Sampling Procedures
- Sample Custody
- Calibration Procedures
- Analytical Procedures
- Data Reduction, Validation, and Reporting
- Internal Quality Control
- Performance and Systems Audit
- Preventative Maintenance
- Data Assessment Procedures
- Corrective Actions
- Quality Assurance Reports

4.0 HEALTH AND SAFETY PLAN

A standard health and safety plan will be developed that will address needs of this work plan. The health and safety plan will contain the following elements:

- Organization
- Health and Safety Risk Analysis
- Employee Training
- Personal Protective Equipment
- Medical Surveillance Requirements
- Site Monitoring Requirements
- Site Control Measures
- Decontamination Procedures
- Standard Operating Procedures for the Site
- Site Contingency Plan
- Entry Procedures for Confined Spaces



LEGEND

== DIRT ROAD

LARK WASTE DUMPS

NOTE:
TOPOGRAPHY DERIVED FROM "1990"
AERIAL MAP.

0 500 1000

SCALE IN FEET

KENNECOTT
UTAH COPPER

LARK MINE
WASTE DUMPS
EXISTING CONDITIONS

Figure 1

2

PROJECT PLANS
FOR
SOUTH JORDAN EVAPORATION PONDS
SITE CHARACTERIZATION

SALT LAKE COUNTY, UTAH

Report 1212V/910623
June 23, 1991
Printed: June 27, 1991 9:31pm

TABLE OF CONTENTS

1.0 OVERALL WORKPLAN

1.1 INTRODUCTION/BACKGROUND STATEMENT

The town of Magna is located in western Salt Lake County near industrial areas used for copper ore concentration and smelting operations, phosphorous ore processing, and a major transportation corridor. The presence of these industrial operations has raised concerns that the local soils may be contaminated with heavy metals. Potential sources of these metals include ore concentrates, blowing tailings dust, smelter particulate emissions, phosphate plant emissions and auto exhaust. Existing chemical data for the soil indicates moderate to low concentrations of heavy metals in the soil. These concentrations are not at levels considered to pose a threat to human health or the environment. However, the data does indicate that some areas may contain elevated levels of certain heavy metals, particularly copper. Although, observed copper concentrations are, in some cases, well above background, they are well below concentrations that would generally considered be a threat to human health. Although available data does not indicate that an environmental problem exists, Kennecott has decided to conduct an additional investigation to further evaluate the concentration of heavy metals in the Magna area soils.

1.2 OBJECTIVES

The objectives for this Plan are:

- To produce quality data for use in evaluating potential impacts to the Magna soils;
- To evaluate the cause of high metal concentrations should they be found;
- To identify areas where additional analyses of the soil may be needed and collect these data.

1.3 SCOPE

The scope of this investigation includes sampling and analyses of soils throughout the Magna Area at approximately 150 locations. A depth profile will be collected and analyzed a each location. The analyses will identify metal concentrations, physical characterization of the soils and potential impurities to the soils.

This investigation is limited to the chemistry of the soil and migration pathways directly related to soil. Samples of air, surface water, and groundwater will not be collected during this investigation. Environmental data previously collected for these other media will be considered during the interpretation of soil data, but only to identify potential causes for elevated levels of metals in Magna soils.

1.4 WORK SCHEDULE

Table 1 - Schedule

YEAR	**1991->**	**<---1992--->**	**<---1993--->**	**<---1994--->**
QUARTER	**.3..4.**	**.1..2..3..4.**	**.1..2..3..4.**	**.1..2..3..4.**
MONTH	**JASOND**	**JFMAMJJASOND**	**JFMAMJJASOND**	**JFMAMJJASOND**
Sampling				
Analysis				

1.5 DELIVERABLES

The deliverable for this project is a report delineating soil metal concentrations in Magna.

2.0 FIELD SAMPLING PLAN

2.1 BACKGROUND

This project consists of the sampling of Magna soils to evaluate the accumulation of heavy metals in the soils.

2.2 OBJECTIVES

The objectives for this sampling program are to collect representative samples for use in the evaluation of the significance and extent of soil contamination, and to evaluate the source of contamination. The first sampling phase will be conducted to evaluate the areal extent and significance of potential metals contamination. If this first phase sampling results in a determination that there is widespread contamination with high metals concentrations, a second sampling phase will be conducted.

2.3 SAMPLING METHODS

2.3.1 Sample location and frequency

The locations of samples to be collected during the first phase of this investigation will be approximately 150 in number. Sample locations will be arranged in a coarse grid considering availability of site access. Should a second phase sampling effort be required, these project plans will be revised to identify any additional sampling points that may be required.

Prior to sampling, exact sampling locations will be specified. The locations will be measured from street corners and will serve to later locate the actual sampling point in the field. The distances will be measured from the starting location using a tape measure. If the point cannot be sampled, the location will be moved to the closest possible point in increments of ten feet. If the closest point is not easily discerned, the closest possible point in the most northerly direction will be selected.

2.3.2 Sample designation

A sample coding system will be used to identify each sample collected during the sampling program. This coding system will provide a tracking record to allow retrieval of information about a particular sample and assure that each sample is uniquely identified.

Each sample is identified by a unique code which indicates the site, sample point and sample depth. An example of the sample identification code is provided below:

MG107a

MG indicates that the sample was collected as part of this sampling effort, 107 is a three letter numerical code that identifies the particular sampling site, and the "a" is a depth code designating the depth of the sample. The depth codes and their definition are provided below:

a-Samples representing the interval between 0 and 2 inches.
b-Samples representing the interval between 2 and 6 inches.
c-Samples representing the interval between 6 and 12 inches.
d-Samples representing the interval between 12 and 18 inches.
aa-Double letter characters will indicate non standard depth intervals, in the event that there is cause to collect them. If multiple non-standard depth intervals are collected, the samples should be named in alphabetical order corresponding with depth.

Duplicate samples will be identified with the characters DUP attached to the end of the name. Matrix spikes and matrix spike duplicates will be identified with the characters MS and MSD attached to the sample name.

2.3.3 Sampling equipment and procedures

<u>Equipment.</u> Table 2 lists the equipment and supplies that will be used in the collection of the soil samples.

Table 2. List of Field Equipment and Supplies

Type of Equipment or Supplies	Quantity
Equipment Boxes	3
First Aid Kits	3
Shovels	3
Stainless Steel Trowels	3
Soil Hand Augers	3
Plastic Spoons	1,000
Styrofoam Cups	2,000
Yard Sticks	3
Ziploc Bags	1,500
Garbage Bags	2 boxes
Duct Tape	2 rolls
Flagging	2 rolls
Cameras	1
Gloves: disposable	
Gloves: leather	
Field Sampling Plan	3
Maps & Photos	
Photo Labels	
Bag Labels	1,000
Paper Towels	
Tap Water Sprayer	
DI Water Sprayer	
Log Books	3
Lab Books	4
Tap Water	
DI Water	
Film	
Compass	3
Jars	2,000

Procedures. A list of Standard Operating Procedures are given in Table 3. Details of these procedures will be provided in a Quality Assurance Program Plan. These procedures will be followed when conducting sampling activities unless conflicting instructions are given in the preceding section.

Table 3. List of Standard Operating Procedures

Procedure Number		Procedure Title
GENERAL	01	Field Book
GENERAL	02	Sample Custody
GENERAL	02.01	Sample Point Marking and Photographic Evidence Documentation
GENERAL	03	Equipment Maintenance and Calibration
GENERAL	03.01	Field Equipment Maintenance
SOIL	01	Sample Collection
SOIL	02	Sample Documentation
SOIL	03	Sample Container Preparation
SOIL	04	Sample Preservation and Packaging
SOIL	05	Equipment Decontamination

2.3.4 Sample Handling and Analysis

Subsequent to the sample collection, all sample documentation will be prepared and the samples handled in accordance with the sample custody procedures outlined in SOP GENERAL-02. The sample documentation will be prepared in accordance with SOP SOIL-02 and will include the following forms and documents:

Field Note Book
Sample Labels
Custody Seals
Chain-of-custody Records
Shipping Documents

All soils samples will be placed in two "ziploc" plastic bags. No preservatives will be used and the samples will be kept at ambient temperatures.

3.0 QUALITY ASSURANCE PROJECT PLAN

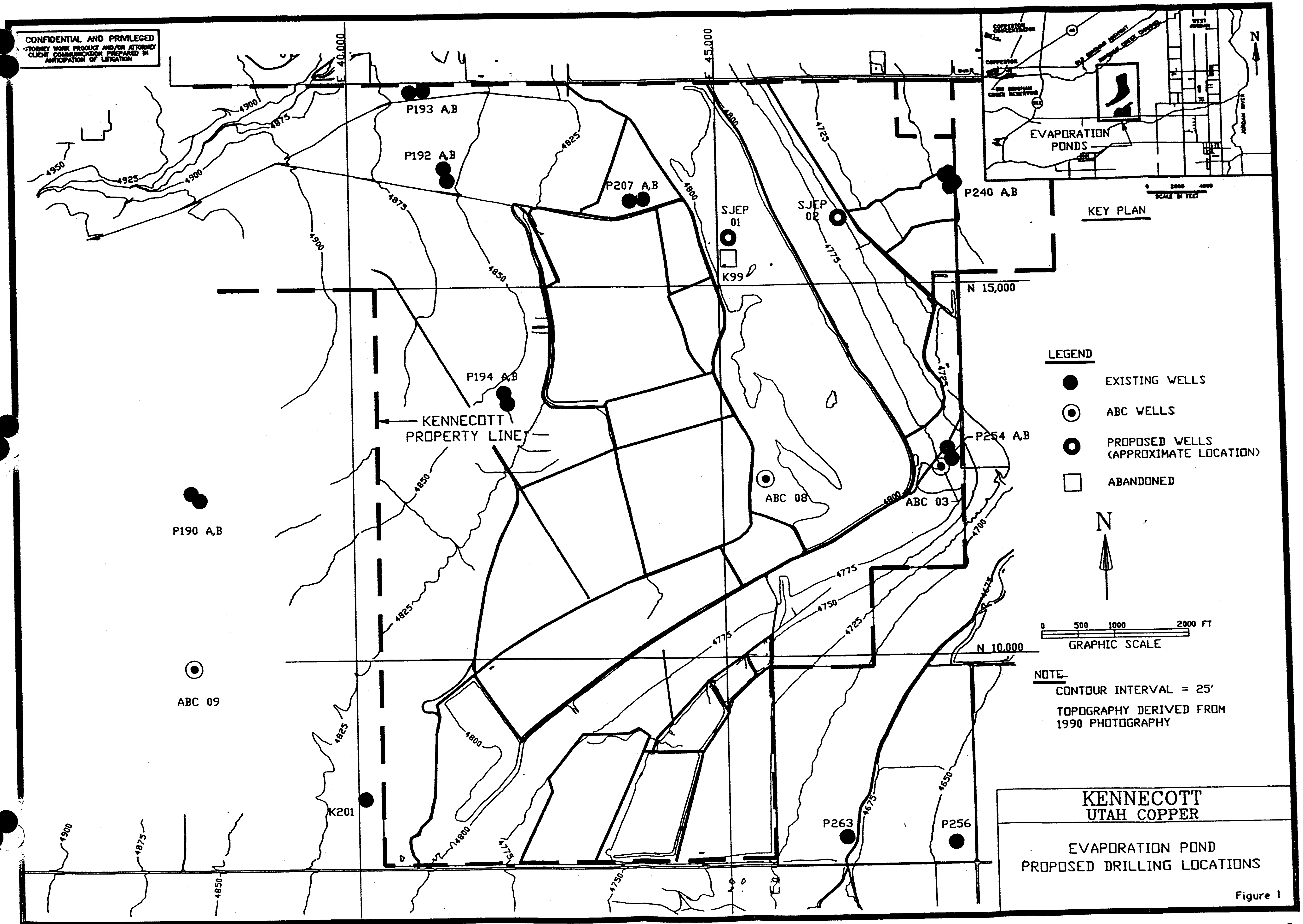
A standard quality assurance program will be developed for the specific needs of this work plan. The plan will contain the following elements:

- Project Description
- Project Organization and Responsibilities
- Quality Assurance Objectives
- Sampling Procedures
- Sample Custody
- Calibration Procedures
- Analytical Procedures
- Data Reduction, Validation, and Reporting
- Internal Quality Control
- Performance and Systems Audit
- Preventative Maintenance
- Data Assessment Procedures
- Corrective Actions
- Quality Assurance Reports

4.0 HEALTH AND SAFETY PLAN

A standard health and safety plan will be developed for the specific needs of this work plan. The plan will contain the following elements:

- Organization
- Health and Safety Risk Analysis
- Employee Training
- Personal Protective Equipment
- Medical Surveillance Requirements
- Site Monitoring Requirements
- Site Control Measures
- Decontamination Procedures
- Standard Operating Procedures for the Site
- Site Contingency Plan
- Entry Procedures for Confined Spaces



KENNECOTT
UTAH COPPER

EVAPORATION POND
PROPOSED DRILLING LOCATIONS

Figure 1

350 foot Monitoring Well

Drilling/Completion:

1. After installing surface casing, drill 6-inch hole to 350 feet by reverse-air.
2. Mud hole and geophysically log the entire hole (see list provided below for geophysical tools to be used).
3. Install 350 feet of 2-inch PVC, schedule 80 pipe, the bottom 100 feet of which is screen.
4. Sand pack screen area with approximately 120 feet of silica sand.
5. Seal remaining annulus with Pure-gold to within 30 feet of surface.
6. Cement upper 30 feet of hole and install protective casing and locking cap.
7. Develop by air-lifting.

Data will be collected as follows:

1. Drill cuttings will be logged continuously.
2. Drill cutting samples will be collected every five feet.
3. Formation fluid field parameters (e.g., pH, conductivity) will be measured every five feet during reverse-air drilling.
4. Water samples will be collected in the reverse-air drilled portion of each hole every 20 feet and a water sample will be collected after completion of the monitoring well.
5. The following geophysical tools will be run after drilling to total depth: gamma ray, neutron, density, induction, micro-resistivity, spontaneous potential, caliper, and temperature. These logs will provide geologic, hydrologic, and geochemical information with depth such as lithology, porosity, hydraulic conductivity, permeability, and water quality.

6. A single well permeability test may be conducted at each well, depending upon the need for additional permeability data at these.

500 foot Monitoring Well

Drilling/Completion:

1. After installing surface casing, drill 6-inch hole to 500 feet by reverse-air.
2. Mud hole and geophysically log the entire hole (see list provided below for geophysical tools to be used).
3. Install 500 feet of 2-inch PVC, schedule 80 pipe, the bottom 100 feet of which is screen.
4. Install approximately 120 feet of silica sand in the screen interval.
5. Seal remaining annular space with Pure-gold to within 30 feet of surface.
6. Cement upper 30 feet of hole and install protective casing and locking cap.
7. Develop by air-lifting.
8. Geophysically log cased hole upon completion (see list provided below for geophysical tools to be used).

Data will be collected as follows:

1. Drill cuttings will be logged continuously.
2. Drill cutting samples will be collected every five feet.
3. Formation fluid field parameters (e.g., pH, conductivity) will be measured every five feet during reverse-air drilling.
4. Water samples will be collected in the reverse-air drilled portion of each hole every 20 feet and a water sample will be collected after completion of the monitoring well.

5. The following geophysical tools will be run after drilling to total depth: gamma ray, neutron, density, induction, micro-resistivity, spontaneous potential, caliper, and temperature. An additional suite of logs (gamma ray, induction, and neutron) will be collected after completion of the monitoring well. These logs will provide geologic, hydrologic, and geochemical information with depth such as lithology, porosity, hydraulic conductivity, permeability, and water quality.

6. A single well permeability test may be conducted at each well, depending upon the need for additional permeability data at these.

Reverse-air drilling will be performed with double-walled drill pipe and appropriate bit. Fluids (water) will not be used with this drilling method, except when necessary due to poor returns, which usually occurs near the water table. Once sufficient formation water is produced, injection of water is not necessary.

2.2.4 Sampling Methods

2.2.4.1 Sample location and frequency

Several different sample types will be collected during the course of the drilling investigation, such as:

1. Drill cuttings
2. Formation water - field parameters
3. Formation water - chemical analysis
4. Formation water - at the end of well development

2.2.4.2 Sample designation

All samples collected from the various drill holes will be numbered in a manner consistent with previous drilling. Samples will be identified by the hole number, the depth, W for water samples, and the sample date. Solid sample numbers will appear the same, except will not include the letter W.

2.2.4.3 Sampling equipment and procedures

Each sample type will require specific equipment and procedures, which will be outlined in various Standard Operating Procedures (SOP). The following provides a list of SOP's which will specifically deal with collection of the various sample types:

1. SOP-101: Collection and handling of drill cuttings: Reverse-air
2. SOP-102: Collection and handling of drive samples
4. SOP-103: Collection of groundwater samples for analysis
5. SOP-104: Preparation of water samples for analysis
6. SOP-105: Solid sample splitting

The SOP's referenced in this document will be provided in a Quality Assurance Program Plan.

2.2.4.4 Sample handing and analysis

Sample handling for each of the anticipated sample types will be discussed in the SOP's listed above. Sample handling will include bagging, transportation, splitting, routing, and storage. The analyses to be performed as part of the groundwater plume study are summarized in Table 2.

Table 2. Chemical Parameters for Groundwater Plume Analyses

PARAMETER	GROUNDWATER	SOLIDS
Acidity/Alkalinity	T	NA
Available Neutralization Potential	NA	T
pH	T	Paste
Specific Conductance	T	Paste
TDS	T	NA
Ca	T	TD; L
Mg	T	TD;L
Na	T	TD; L
K	T	TD; L
HCO3/CO3	T	NA
Cl	T	NA
SO_4	T	TD; L
B	T	Na
Li	T	TD
Sr	T	TD
F	T	NA
$NO_3 + NO_2$	T	NA
As	D	TD
Ba	D	TD
Cd	D	TD
Cr (Total)	D	TD
Co	D	TD
Cu	D	TD
Fe	D	TD
Pb	D	TD

PARAMETER	GROUNDWATER	SOLIDS
Mn	D	TD
Se	D	TD
Ag	D	TD
Zn	D	TD
Gross Alpha	D	NA
Gross Beta	D	NA
Ra-226+228	D	NA
U	D	NA

1. D: Dissolved
   T: Total
   TD: Total Digestible
   L: Leachable
   NA: Not Applicable to this phase

2. Analyses will be performed using the procedures of USEPA, 1986, Test methods for Evaluating Solid Waste, Physical/Chemical Methods: SW-846, third edition, except as follows:

   The following tests will be performed using the test procedures developed by KEL/ABC in 1990:

   o Available Neutralization Potential

   o Leachable Sulfate and Leachable Cations

   These test methods are presented in ABC, 1990, Laboratory Test Results... In addition, the test procedures are on file with KEL, where they are available for review on reasonable notice.

3. Minimum detection limits will be those of the EPA Contract Laboratory Program Routine Analytical Services, except that the detection limit for ANP will be 10 mg CaCO3 equivalent per kg solid, and the detection limit for Leachable Species will be 10 mg/kg.

2.2.4.5 Sample Paperwork

Traffic reports. Traffic reports will not be used in this project. Chain of custody forms will be used to track the progress of the various samples.

Chain of custody form. A chain of custody form will be used in all circumstances.

SAS packing list. SAS packing list does not apply to this program.

Sample tags. Sample tags consistent with the previous drilling program will be used. The specific labeling procedures are outlined in SOP-104 (Sample labeling).

2.2.5 Deliverables

A well report will be produced for each well drilled, and will include the following:

1. Purpose of the well
2. Description of the drilling and completion a
3. Geologic description and pictoral log of the hole
4. Geophysical logs of the hole (if any)
5. Description of the sampling performed
6. Results of the sampling/testing at the well site
7. Results of laboratory testing (when available)

2.3 AIR MONITORING PROGRAM

2.3.1 Background

Because particulates from the evaporation pond area are potentially of concern, an air monitoring station is proposed for the pond vicinity.

2.3.2 Objectives

The objective of this program is to monitor particulates in the vicinity of the evaporation ponds to establish whether material is leaving the pond area via the atmosphere. If particulates are leaving the pond area, an air station will establish the nature and quantity of material in transit.

2.3.3 Technical Approach

A visual assessment of windborne particulates which are currently generated from the evaporation ponds, and an assessment of the potential effects of remediation on windborne particulates will be used to establish the location of the air monitoring station and define the monitoring program. One project-specific local monitoring station will be located between the evaporation ponds and the closest residential area (South Jordan), based on the prevailing wind direction and an available site.

Air monitoring will consist of particulate measurement using an air filtering device. Particles collected on the filter will be weighed and analyzed for specific metals. Air gases will not be monitored. Related parameters, such as wind speed and direction, precipitation, and temperature will also be measured and recorded at the monitoring station.

2.3.4 Scope of Work

The initial task is the installation of the monitoring station. Monitoring will be on a prescribed, regular basis, and will continue through site characterization. Particles will be collected on a 24-hour basis.

2.3.5 Deliverables

An air monitoring report, describing the monitoring station installation and presenting monitoring data and results through the site characterization will be prepared.

3.0 QUALITY ASSURANCE PROJECT PLAN

A standard quality assurance program will be developed for the specific needs of this work plan. The plan will contain the following elements:

- Project Description
- Project Organization and Responsibilities
- Quality Assurance Objectives
- Sampling Procedures
- Sample Custody
- Calibration Procedures
- Analytical Procedures
- Data Reduction, Validation, and Reporting
- Internal Quality Control
- Performance and Systems Audit
- Preventative Maintenance
- Data Assessment Procedures
- Corrective Actions
- Quality Assurance Reports

4.0 HEALTH AND SAFETY PLAN

A standard health and safety plan will be developed for the specific needs of this work plan. The plan will contain the following elements:

- Organization
- Health and Safety Risk Analysis
- Employee Training
- Personal Protective Equipment
- Medical Surveillance Requirements
- Site Monitoring Requirements
- Site Control Measures
- Decontamination Procedures
- Standard Operating Procedures for the Site
- Site Contingency Plan
- Entry Procedures for Confined Spaces

PROJECT PLANS
FOR
MAGNA SOILS
SITE CHARACTERIZATION

SALT LAKE COUNTY, UTAH

Report 1212E/910624
June 24, 1991
Printed: June 27, 1991 9:24pm

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1.0 OVERALL WORKPLAN

1.1 INTRODUCTION/BACKGROUND STATEMENT

The town of Magna is located in western Salt Lake County near industrial areas used for copper ore concentration and smelting operations, phosphorous ore processing, and a major transportation corridor. The presence of these industrial operations has raised concerns that the local soils may be contaminated with heavy metals. Potential sources of these metals include ore concentrates, blowing tailings dust, smelter particulate emissions, phosphate plant emissions and auto exhaust. Existing chemical data for the soil indicates moderate to low concentrations of heavy metals in the soil. These concentrations are not at levels considered to pose a threat to human health or the environment. However, the data does indicate that some areas may contain elevated levels of certain heavy metals, particularly copper. Although, observed copper concentrations are, in some cases, well above background, they are well below concentrations that would generally considered be a threat to human health. Although available data does not indicate that an environmental problem exists, Kennecott has decided to conduct an additional investigation to further evaluate the concentration of heavy metals in the Magna area soils.

1.2 OBJECTIVES

The objectives for this Plan are:

- To produce quality data for use in evaluating potential impacts to the Magna soils;
- To evaluate the cause of high metal concentrations should they be found;
- To identify areas where additional analyses of the soil may be needed and collect these data.

1.3 SCOPE

The scope of this investigation includes sampling and analyses of soils throughout the Magna Area at approximately 150 locations. A depth profile will be collected and analyzed a each location. The analyses will identify metal concentrations, physical characterization of the soils and potential impurities to the soils.

This investigation is limited to the chemistry of the soil and migration pathways directly related to soil. Samples of air, surface water, and groundwater will not be collected during this investigation. Environmental data previously collected for these other media will be considered during the interpretation of soil data, but only to identify potential causes for elevated levels of metals in Magna soils.

1.4 WORK SCHEDULE

Table 1 - Schedule

YEAR	**1991->**	**<---1992--->**	**<---1993--->**	**<---1994--->**
QUARTER	**.3..4.**	**.1..2..3..4.**	**.1..2..3..4.**	**.1..2..3..4.**
MONTH	**JASOND**	**JFMAMJJASOND**	**JFMAMJJASOND**	**JFMAMJJASOND**
Sampling				
Analysis				

1.5 DELIVERABLES

The deliverable for this project is a report delineating soil metal concentrations in Magna.

2.0 FIELD SAMPLING PLAN

2.1 BACKGROUND

This project consists of the sampling of Magna soils to evaluate the accumulation of heavy metals in the soils.

2.2 OBJECTIVES

The objectives for this sampling program are to collect representative samples for use in the evaluation of the significance and extent of soil contamination, and to evaluate the source of contamination. The first sampling phase will be conducted to evaluate the areal extent and significance of potential metals contamination. If this first phase sampling results in a determination that there is widespread contamination with high metals concentrations, a second sampling phase will be conducted.

2.3 SAMPLING METHODS

2.3.1 Sample location and frequency

The locations of samples to be collected during the first phase of this investigation will be approximately 150 in number. Sample locations will be arranged in a coarse grid considering availability of site access. Should a second phase sampling effort be required, these project plans will be revised to identify any additional sampling points that may be required.

Prior to sampling, exact sampling locations will be specified. The locations will be measured from street corners and will serve to later locate the actual sampling point in the field. The distances will be measured from the starting location using a tape measure. If the point cannot be sampled, the location will be moved to the closest possible point in increments of ten feet. If the closest point is not easily discerned, the closest possible point in the most northerly direction will be selected.

2.3.2 Sample designation

A sample coding system will be used to identify each sample collected during the sampling program. This coding system will provide a tracking record to allow retrieval of information about a particular sample and assure that each sample is uniquely identified.

Each sample is identified by a unique code which indicates the site, sample point and sample depth. An example of the sample identification code is provided below:

MG107a

MG indicates that the sample was collected as part of this sampling effort, 107 is a three letter numerical code that identifies the particular sampling site, and the "a" is a depth code designating the depth of the sample. The depth codes and their definition are provided below:

a-Samples representing the interval between 0 and 2 inches.
b-Samples representing the interval between 2 and 6 inches.
c-Samples representing the interval between 6 and 12 inches.
d-Samples representing the interval between 12 and 18 inches.
aa-Double letter characters will indicate non standard depth intervals, in the event that there is cause to collect them. If multiple non-standard depth intervals are collected, the samples should be named in alphabetical order corresponding with depth.

Duplicate samples will be identified with the characters DUP attached to the end of the name. Matrix spikes and matrix spike duplicates will be identified with the characters MS and MSD attached to the sample name.

2.3.3 Sampling equipment and procedures

Equipment. Table 2 lists the equipment and supplies that will be used in the collection of the soil samples.

Table 2. List of Field Equipment and Supplies

Type of Equipment or Supplies	Quantity
Equipment Boxes	3
First Aid Kits	3
Shovels	3
Stainless Steel Trowels	3
Soil Hand Augers	3
Plastic Spoons	1,000
Styrofoam Cups	2,000
Yard Sticks	3
Ziploc Bags	1,500
Garbage Bags	2 boxes
Duct Tape	2 rolls
Flagging	2 rolls
Cameras	1
Gloves: disposable	
Gloves: leather	
Field Sampling Plan	3
Maps & Photos	
Photo Labels	
Bag Labels	1,000
Paper Towels	
Tap Water Sprayer	
DI Water Sprayer	
Log Books	3
Lab Books	4
Tap Water	
DI Water	
Film	
Compass	3
Jars	2,000

Procedures. A list of Standard Operating Procedures are given in Table 3. Details of these procedures will be provided in a Quality Assurance Program Plan. These procedures will be followed when conducting sampling activities unless conflicting instructions are given in the preceding section.

Table 3. List of Standard Operating Procedures

Procedure Number		Procedure Title
GENERAL	01	Field Book
GENERAL	02	Sample Custody
GENERAL	02.01	Sample Point Marking and Photographic Evidence Documentation
GENERAL	03	Equipment Maintenance and Calibration
GENERAL	03.01	Field Equipment Maintenance
SOIL	01	Sample Collection
SOIL	02	Sample Documentation
SOIL	03	Sample Container Preparation
SOIL	04	Sample Preservation and Packaging
SOIL	05	Equipment Decontamination

2.3.4 Sample Handling and Analysis

Subsequent to the sample collection, all sample documentation will be prepared and the samples handled in accordance with the sample custody procedures outlined in SOP GENERAL-02. The sample documentation will be prepared in accordance with SOP SOIL-02 and will include the following forms and documents:

Field Note Book
Sample Labels
Custody Seals
Chain-of-custody Records
Shipping Documents

All soils samples will be placed in two "ziploc" plastic bags. No preservatives will be used and the samples will be kept at ambient temperatures.

3.0 QUALITY ASSURANCE PROJECT PLAN

A standard quality assurance program will be developed for the specific needs of this work plan. The plan will contain the following elements:

- Project Description
- Project Organization and Responsibilities
- Quality Assurance Objectives
- Sampling Procedures
- Sample Custody
- Calibration Procedures
- Analytical Procedures
- Data Reduction, Validation, and Reporting
- Internal Quality Control
- Performance and Systems Audit
- Preventative Maintenance
- Data Assessment Procedures
- Corrective Actions
- Quality Assurance Reports

4.0 HEALTH AND SAFETY PLAN

A standard health and safety plan will be developed for the specific needs of this work plan. The plan will contain the following elements:

- Organization
- Health and Safety Risk Analysis
- Employee Training
- Personal Protective Equipment
- Medical Surveillance Requirements
- Site Monitoring Requirements
- Site Control Measures
- Decontamination Procedures
- Standard Operating Procedures for the Site
- Site Contingency Plan
- Entry Procedures for Confined Spaces